

**ENVIRONMENTAL IMPACT ASSESSMENT
IN THE ROUTING OF
HIGH VOLTAGE OVERHEAD TRANSMISSION LINES:
THEORY AND PRACTICE IN SOUTH AFRICA**

by

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There is no substitute for energy; the whole edifice of modern life is built upon it. Although energy can be bought and sold like any other commodity, it is not "just another commodity", but the precondition of all commodities, a basic factor equally with air, water and earth.

E F Schumaker

(Quoted in *Schumaker on Energy*, edited by Geoffrey Kirk, 1982.

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This is for Allan Lawson (MBChB) 1918 -1981, and for Helene Lawson (BSc).

SUMMARY

This study resulted from a perception held by the author that more attention is afforded to complying with the procedural elements of Environmental Impact Assessment (EIA) in South Africa, than to ensuring the validity of its technical content. The routing of high voltage overhead transmission lines provides a relevant field of study in which to address this perception.

An initial literature review to contextualise the perceived problem showed that the questionable validity of the technical content of EIA was one of six shortcomings identified. To address the problem, an inductive approach was adopted to focus on the interpretation and prediction activities of EIA and two propositions, stated as research questions for discussion, were developed. These referred to the theoretical question of whether methods are specified for high voltage overhead transmission line EIAs, and to the practical question of whether the environmental impacts that are known to result from transmission line projects are effectively addressed in such EIAs in South Africa. Investigating these questions provides insights into whether the technical content of transmission line EIA is sufficiently rigorous in South Africa.

The method of study takes the form of a sequentially more focused examination of the literature on EIA, from the strategic level, to the sectoral level and culminating at the project level. EIA methods specified for linear developments were identified at the sectoral level, while at the project level the known environmental impacts that result from high voltage overhead transmission lines were determined. A theoretical background was compiled in this way, which allowed for comparison with the practice as determined from benchmark and case study Environmental Impact Reports (EIRs).

It was found that at the theoretical level, of the 18 EIA methods identified, two were specified for use in linear development projects (tabulation and overlay mapping), while five other methods were regarded as being adaptable to different types of developments. Comparison with practice in the benchmark and case study EIRs, however, showed that tabulation and overlay mapping were not as widely used as expected - i.e. used in about half of the EIRs examined - and that simple descriptive text and non-overlay mapping were about as frequently used. Numerical manipulation in the form of one of the other five adaptable methods (Sondheim) was also used, in slightly less than half the cases. The conclusion is that the specified EIA methods are not always used for high voltage overhead transmission line route selection, but such a conclusion is not definitive nor is it an indictment.

At the more detailed level, known transmission line environmental impacts were grouped into biophysical, socio-economic and electrotechnical factors. The examination of the case study EIRs resulted in a tabulated rating of the effectiveness of transmission line EIA practice in South Africa. This was done by awarding each determinant of a known impact in each case study a rating according to four criteria: impact not recognised; impact recognised but not evaluated; impact recognised and evaluated; and evaluation of impact resulted in mitigation. These tables, or effectiveness matrices, showed that the biophysical and socio-economic factors received more attention than the electrotechnical factors. An inductive generalisation was possible, that the known environmental impacts that result from high voltage overhead transmission lines are reasonably effectively addressed in South Africa.

The conclusion of this study is that the perceived problem in transmission line EIA in South Africa, of neglect of the validity of its technical content, is largely unfounded.

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GLOSSARY OF TERMS

ANALYSIS:

The act of studying and interpreting data, situations or concepts, in order to attain an understanding of their meaning and relevance to some decision.

ASSESSMENT:

The process of identifying, collecting, analysing, interpreting and communicating data that are relevant to some decision, as well as monitoring the subsequent actions (cf. environmental impact assessment).

CIRCUIT:

A set of conductors, insulated from each other, through which electric current is intended to flow.

CONDUCTOR:

A wire or combination of wires not insulated from one another, designed to carry electric current; may be bare or insulated.

CORONA:

A luminous electric discharge resulting from the breakdown of the insulating properties of the air surrounding a conductor.

CORRIDOR:

A narrow linear feature in a landscape that contains visual elements different to those on either side of the corridor (cf. utility corridor).

DEVELOPMENT PROPOSAL:

A proposal directed at increasing the flow of benefits from the existing resource base by reallocating resources and modifying the environment in order to improve social well-being.

ELECTRIC FIELD:

A state existing in a medium between two bodies at two different electric potentials; if an electric charge were placed there, it would have a force exerted on it tending to make it move.

ENVIRONMENT:

The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group.

ENVIRONMENTAL EVALUATION:

The process of obtaining, organising and weighing information on the consequences, or impacts, of alternatives; an element within the environmental impact assessment process.

ENVIRONMENTAL IMPACT:

An environmental change caused by some human act.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA):

(1) An activity designed to identify and predict the impact on human health and well-being of legislative, policy, programme and project proposals, as well as operational procedures, and to interpret and communicate information about such impacts (cf. assessment).

(2) The administrative process by which the environmental impacts of alternative proposed actions are determined, and adverse consequences that

are predicted are investigated and documented, with the primary purpose of providing decision-makers with information to facilitate their choice among alternatives.

(3) A means whereby mitigatory measures that reduce negative impacts, and activity modifications that enhance positive impacts, can be formulated for development proposals (cf. Integrated Environmental Management).

EIA METHOD:

(1) The complete range of structured activities required to identify, measure and collect information relevant to the environmental impacts of development proposals, to analyse and interpret this information for prediction purposes, to communicate the findings, and to monitor subsequent actions; EIA methods may also be applied to legislative proposals, policies, programmes and operational procedures, although not in this study (cf. method).

(2) Recent emphasis is on the process embodied in EIA method and the iterative decision-making required; better integration of its predictive role, particularly during the design stage of a proposed development, is resulting in a more substantive influence being exercised by EIA.

ENVIRONMENTAL IMPACT REPORT (EIR):

A document which provides an analysis of the impacts associated with a development proposal; the formal documentation of an EIA.

ENVIRONMENTAL ISSUE:

A concern felt by one or more parties about some existing or potential environmental impact.

FIRST-ORDER IMPACTS:

Impacts which are a direct result of some action.

FLASHOVER:

An electrical arc from one electrically charged object to another.

GOOD (noun):

Any tangible or intangible thing which can provide utility (cf. utility).

HIGH VOLTAGE TRANSMISSION LINES:

Electrical transmission lines that carry a voltage greater than 30 000 volts.

HIGHER-ORDER IMPACTS:

Impacts which arise from other impacts.

IMPACT:

The outcome of an action, whether considered desirable or undesirable.

INDUCTANCE:

The property of an electrical circuit whereby an alternating current induces a magnetic field; this magnetic field may induce a voltage in that circuit or a neighbouring circuit.

INTEGRATED ENVIRONMENTAL MANAGEMENT (IEM):

A procedure designed to ensure that the environmental consequences of development proposals are understood and adequately considered during the planning process, allowing negative aspects to be resolved or mitigated and positive aspects to be enhanced; a philosophy which describes a code of practice for ensuring that environmental considerations are fully integrated into all stages of development.

MAGNITUDE:

A determination of the scale of an environmental impact, from a technical point of view.

METHOD:

A general type of procedure chosen to direct a scientific enquiry (cf. EIA method).

OUTAGE:

A temporary disconnection of a part of an electrical system as the result of either a fault or scheduled maintenance.

POWER TRANSFER:

The transportation of electric power via conductors connecting two or more terminal stations or areas.

PROCEDURE:

A series of prescribed steps for guiding or accomplishing a scientific inquiry.

PROJECT EIA:

Also referred to as sub-sectoral EIA, this is the lowest and most detailed level of EIA, since it is specific to a particular project.

SCOPING:

A procedure for narrowing the focus of an EIA and ensuring that it remains centred on the significant issues, impacts and alternatives.

SCREENING:

A procedure for determining the appropriate level of EIA; in the IEM procedure this entails the classification of development proposals.

SECTORAL EIA:

The application of EIA at the level of particular categories of economic activity, such as agricultural, energy, industrial, mining, tourism, transportation etc., at a lower level than strategic EIA (cf. strategic EIA) but a higher level than project EIA (cf. project EIA).

SERVITUDE:

Statutory right of way to pass over another's property, acquired for a defined purpose.

SIGNIFICANCE:

A determination of the social importance of an environmental impact; difficult to measure objectively.

SIGNIFICANT IMPACT:

An environmental impact which is regarded as important to social well-being; an environmental impact that has crossed the threshold of significance.

SOCIAL IMPACT ASSESSMENT:

An EIA that is specifically directed at identifying and analysing impacts to social groups.

STRATEGIC EIA:

The application of EIA in strategic planning, policy making and legislation formulation, at the highest level, i.e. higher than sectoral EIA (cf. sectoral EIA) and project EIA (cf. project EIA).

SUSTAINABLE DEVELOPMENT:

Development that meets present needs without compromising future generations' ability to meet their own needs; implies living within the carrying capacity of supporting ecosystems.

TRANSMISSION LINE (OVERHEAD):

The conductors and their supporting towers, used to convey electric energy from one point to another.

UTILITY:

The satisfaction, pleasure or need-fulfilment derived from consuming some quantity of a good.

UTILITY CORRIDOR:

A corridor providing direct economic benefit by transporting people, goods or services across a landscape; overhead electrical transmission lines are an example, others being roads and highways, railway lines, canals, pipelines and telephone lines (cf. corridor).

CHAPTER 1: INTRODUCTION

It is self-evident that energy is an essential human commodity. It provides the means whereby basic life-supporting activities like cooking, heating, transportation, manufacturing and mechanical work are possible. Schumacher (1973:101) regards energy availability as the precondition of all other commodities. He equates it with air, water and soil as factors of central importance to the human condition.

Humankind requires energy to perpetuate its progress into the future. Sources that are both environmentally sustainable as well as technologically efficient need to be maintained and further developed. This is necessary to meet the increasing energy demand resulting from continued human development. The concept of sustainable development is relevant here. Hill and Bowen (1996) make the point that no clear and unambiguous definition has yet received acceptance, due to different disciplines awarding their own meanings to the term. For the purpose of this study, however, sustainable development is understood to mean that future generations' energy needs are not compromised by meeting present needs (World Commission on Environment and Development, 1987:43), and that humankind should live within the carrying capacities of supporting ecosystems (World Conservation Union, 1991).

Energy comprises various products and services and the World Commission on Environment and Development (1987:202) has called for these to be ordered in a viable strategy that can meet energy needs in the future. One way of improving

the sustainability of energy supply is to improve the efficiency of energy use. The burning of primary fuels like wood and coal is an inefficient utilisation of energy, since much of the heat escapes unused. Electricity, however, is a secondary form of energy, since the primary form of fuel in its raw state is already converted for direct use in motors, appliances etc. As such, electricity provides a cleaner and more efficient source of energy for the end-user, as well as contributing to the sustainability of energy sources, because of the increased efficiency of use.

In South Africa, 64 % of households do not have access to electricity (African National Congress, 1994:31), although more than 50 % of the continent's generated capacity derives from this country (Eskom, 1992:2). Without entering into the debate on the environmental appropriateness of various sources, it is accepted that the provision of energy in the form of electricity to those who presently do not have access to it, will be a national priority for several years (African National Congress, 1994:33). South Africa's major electricity utility, Eskom, has committed itself to electrifying 1,75 million households between 1994 and 2000 (Eskom, 1995:32) and is confident of meeting this target. New domestic connections totalled 378 171 in 1994 (Eskom, 1994a:19) and 313 179 in 1995 (Eskom, 1995:32). For the purposes of this study, a critical assumption is thus that electricity transportation in bulk will continue to be a feature of our various landscapes.

In terms of engineering and direct monetary costs, high voltage overhead transmission lines are the most efficient means of bulk electricity transport and in 1995 there were 241 802 km of powerlines in use in South Africa (Eskom, 1995:1). The strips of land occupied by powerlines, as well as roads and highways,

railway lines, canals and telephone lines, are referred to as utility corridors. Corridors are broadly defined as narrow linear features that contain landscape elements different to those on either side of the corridor (Forman and Godron, 1986:123). The concept is dealt with in more detail later in this study but as an introduction, it is sufficient to note that utility corridors provide routes of transport for a variety of human commodities.

Besides the extensive network of powerline servitude corridors referred to in the previous paragraph, 184 330 km of rural road corridors were recorded by Macdonald (1989:62) in South Africa in 1984. To further illustrate the extent of the phenomenon, in excess of 800 000 km of various utility corridors were already in use in the United States of America (USA) by 1979 (Ross, 1979:55). The significance of the impact of utility corridors on the global environment is thus unequivocal.

The development of utility corridors has seen the same concerns being expressed about the environmental consequences of such projects as other major developments. This was part of the emergence early in the 1970s of ways to ensure that environmental factors were taken into account in the planning of development projects. Public concern about the environmental consequences of resource development schemes was the result of the increased scale and pace of such developments. Until the early 1970s, development projects had usually only been assessed on the conventional economic and technical aspects typical of the era (Clark, 1984:3). Wathern (1988:21) confirms this in his observation that cost benefit analysis, aimed specifically at economic appraisal, was the most extensively used evaluation technique prior to the general adoption of Environmental Impact Assessment (EIA). In broad terms, EIA may be defined as

a means of analysis that predicts the possible physical and social effects on the environment resulting from development proposals, policies or plans. The concept is dealt with in more detail in sections 2.1. and 2.3. below.

As an environmental management tool, EIA has become a generally accepted means of intervening in the decision-making process in development proposals. Probably the most significant move towards this acceptance was the requirement contained in the 1969 National Environmental Policy Act in the USA, whereby EIAs became statutory prerequisites for major federal activities. Several industrialised countries followed suit in the next decade, non-industrialised countries also began to institute such procedures, and the European Community eventually adopted a mandatory assessment approach in 1985 (Wathern, 1988:3).

In South Africa, the Environment Conservation Act, Number 73 of 1989 (Republic of South Africa, 1989), provides for control over development proposals, but only if the administrative authority is exercised. Enabling regulations are presently being proposed, which will make EIA a legal requirement for certain activities. Nevertheless, a procedural and regulatory mechanism for EIA is provided for in South Africa, with the development of the Integrated Environmental Management (IEM) procedure. This was proposed by the Council for the Environment in 1989 and has received national acceptance. Much of the terminology in this work is derived from the glossary provided in the IEM documents (Department of Environment Affairs, 1992).

Several specialised areas of study have emerged more recently under the umbrella of EIA. Prominent among these are the studies related to the social and

health implications of developments. Modern technologies are now also being subjected to assessment. New techniques and skills are becoming established with the unfolding of these new areas of study in EIA (Julien, 1995:403).

In the spirit of improvement and development, this study investigates the effectiveness of specific EIA methods. These are the methods that are applied, in South Africa, to a subset of utility corridors, namely the route selection for high voltage overhead electrical transmission lines.

This study was prompted by concern about the effectiveness with which EIA is practised in South Africa, with a focus on the EIA of high voltage overhead electrical transmission lines. It is the author's perception that more attention is afforded to the procedural elements of EIA in South Africa, than to the validity of its technical content. This is discernible in the emphasis on the sequence of steps prescribed by the IEM procedure (Department of Environment Affairs, 1992). The proponents of development projects often place much store in making available the documentation prescribed by the steps in the IEM procedure, in the belief that the perceived hindrance of EIA can be alleviated in this way. In the electricity utility industry in South Africa, for instance, some EIAs that have been undertaken and which contain the required procedural elements, should rather be seen as exercises in mitigation, since the EIA practitioners are not always able to influence the strategic "go/no go" decision (Lawson, 1995:88). Another example of reliance on the documentation prescribed by the steps in the IEM procedure can be seen in the independent development by the Department of Water Affairs and Forestry of Relevant Environmental Impact Prognoses at particular stages in their development proposals. These are documents used in the application of EIA in which available information is synthesised, to allow for the proposal to move to the next stage of the procedure (Louw, pers. comm.).

High voltage overhead transmission line route selection is the author's particular area of experience and is thus the best understood realm within which to investigate the perceived lack of attention to the technical content of EIA in South Africa.

The importance of providing electricity to those in society who presently do not have it, was emphasised in the previous chapter. High voltage overhead transmission lines are necessary to distribute electricity and these require utility corridors. The effectiveness of route selection methods for these transmission lines is an important field of study, given the massive and legitimate need for electrification at this time in South Africa's history. When briefed with such utility corridor planning in particular, the EIA practitioner faces problems additional to those related to site-specific development proposals, since the more complex the project is, the more difficult it becomes to predict all of the impacts in quantifiable units (Atkins, 1984:242).

The study necessarily begins with a broad examination of the literature on EIA, i.e. an initial literature review, to enable the perceived problem to be contextualised. This is provided in section 2.1. Thereafter, a comprehensive statement of the need for investigation of the perceived problem is given in section 2.2. This is followed by sections 2.3. and 2.4., which described the scope and method of the study respectively. The final section of this chapter (section 2.5.) then states the propositions that the study sets out to test, in meeting the need for investigating the perceived problem.

2.1. CONTEXT WITHIN WHICH THE PROBLEM IS DESCRIBED

The initial literature review, discussed below, identified various shortcomings in EIA methods. EIA method is understood to encompass the complete range of structured activities required to identify, measure and collect information

relevant to the environmental impacts of development proposals, to analyse and interpret this information for prediction purposes, to communicate the findings, and to monitor subsequent actions. These structured activities should occur within an iterative and integrated process of decision-making.

Different types of actions can be subjected to EIA, at different levels of authority. Wood (1988:98-99) proposes a hierarchy, from high-level EIAs of policy actions at a national level, to low-level EIAs for localised projects. More recently, the concepts of strategic EIA and sectoral EIA have emerged (World Bank, 1993; United Nations, 1994:2; Dalal-Clayton and Sadler, 1995). Strategic EIA is aimed at macro planning and legislative and policy proposals, at high levels of government. Sectoral EIA is applied at the level of specific types of development, such as the agricultural, energy, industrial, mining, tourism and transportation sectors of the economy. The lowest level in the hierarchy remains the detailed project EIA and methods are better developed at this level than at the strategic and sectoral levels (Wood, 1988:113).

The sectors relevant to high voltage overhead transmission lines are those pertaining to energy and transportation. However, since the transmission of electricity has more to do with transportation than with energy, this study regards the EIA of high voltage overhead transmission lines as a subset of the transportation sector. The study ultimately focuses on EIA methods at the project level, as applied to high voltage overhead electrical transmission line planning in particular.

The following is the array of shortcomings in the application of EIA that was encountered in the initial literature review:

- A lack of consistency in the use of EIA terminology.
- Resource and time constraints in conducting EIAs.
- Independent development of EIA methods by practitioners.
- Subjectivity on the part of EIA practitioners.
- A lack of integration of EIA and other disciplines.
- Questionable validity of the technical content of EIA.

Each of these is now briefly described, to provide a context for the concern about the technical content of EIA.

There is a lack of consistency in the terminology encountered in the literature reviewed. This lack of consistency is particularly noticeable in the literature that deals with the elements of description and analysis in EIA methods. Many of the EIA methods described in the literature are designated by disparate terminology. Compare, for example, Caldwell (1982, cited in Wathern, 1988:16) and Thompson (1990), where different terminology is used to designate EIA methods common to both studies; when describing the EIA method developed by Dee *et al* (1973), the former refers to the "*Environmental Evaluation System*", while the latter refers to the "*Battelle methodology*".

Most of the published material dealing with applied EIA methods is derived from the developed countries of the northern hemisphere (Fuggle, 1992:748), where more resources and a better proceduralised approach pertain. It can be questioned whether EIA methods that have emerged from developed countries can be used unchanged in developing countries. Lemons and Porter (1992:64), for instance, have reported that data resource problems in particular, are a limiting factor in the practice of EIA in developing countries. Also, EIAs are frequently conducted under severe time constraints in parts of the world where the provision of basic human needs such as food and shelter is awarded priority.

Evidence of accelerated EIA is found in the concept of rapid assessment, dealt with in the urban context, for example, by Leitmann (1993:225-260). In South Africa, a Streamlined Environmental Impact Assessment (SEIA) process has been initiated by the Council for the Environment (1994), to meet the priority needs of the Reconstruction and Development Programme (RDP) of the post-Apartheid government. Caution is clearly required in the application in developing countries of EIA methods formulated in the developed countries.

The documentation of actual impact studies, in the form of Environmental Impact Reports (EIRs), often provides only limited reference to the choice of EIA methods. Out of a total of 348 assessments examined by Caldwell (1982, cited in Wathern, 1988:16), 106 could not be allocated to a list of theoretically based, and thus well established, methods identified by the study. Thus, close to one third of the EIAs that were examined did not make use of any of these discrete methods, but were based on *ad hoc* approaches. This lack of use of known methods indicates that in the USA, where EIA has its longest history, considerable independent development was still occurring more than a decade after the promulgation of the National Environmental Policy Act in 1969.

The evaluations undertaken in EIAs are often subjective, based as they are on the personal, professional and institutional value judgements of the responsible practitioners (Munn, 1979:162). The Ministerie van Volksgezondheid en Milieuhygiene (1981:46) emphasised the importance of a structured and organised approach to EIA, to better manage this subjectivity. The apparent lack of a common understanding of related terminology, of theoretical approaches, of the hierarchy of strategic, sectoral and project EIA, and of the interaction between science and art in EIA seems to hinder the establishment of a structured

yardstick against which practitioners can measure their evaluations and analyses. (The relationship between science and art in EIA is further described in sections 2.2. and 2.3. below.)

The environmental implications of development proposals need to be accounted for through integrated planning and decision-making (Clark, 1984:11). However, there is little clarity about the ways in which such integration is to be brought about. It is the author's perception that the lack of integration of EIA with the other disciplines involved in development projects, is reflected in the diversity of EIA methods used. A manifestation of this is the independent development of EIA methods discussed earlier in this section. Although there are global differences in administrative structures and procedural frameworks for EIA, few of these integrate the choice of EIA method as a procedural step early in the entire development process. Wathern (1988:29) maintains that the further development of EIA depends on improving the integration of its various components. Brown and Hill (1995) argue specifically for environmental input to exert greater influence over the design of a project while it is developing and evolving. This would result in EIA becoming better integrated with the entire process and allow for more substantive influence over the decision-making iterations.

The literature reviewed generally describes in more detail the procedural aspects of EIA, rather than how the measurable technical aspects can be validated. It is important to differentiate between how well the steps in the administration and regulation of the entire EIA process are met, and the validity of the technical information dealt with. On the one hand, meeting the proceduralised steps in the process runs the risk of simply achieving compliance by "jumping through hoops". On the other hand, ensuring that the technical information

required in the process is valid, at least allows for good science to be brought to bear in the decision-making process.

Out of the array of shortcomings described above, examining the validity of the technical content of EIA, without particular attention to the steps in the process, is believed to be a cogent means of revealing the effectiveness of the practice, as it is applied in high voltage overhead transmission line routing in South Africa.

2.2. SYNOPTIC PROBLEM AND NEED STATEMENT

Environmental impact assessment deals with both the technical, specialised aspects of a development proposal, as well as with the decision-making stages embedded within the entire EIA process. The size or magnitude of an impact that could result from a development proposal is more easily measurable than is the significance of the impact in terms of its importance to society. EIA thus consists of distinct elements of science and of art, with the art component having relevance to the decision-making process that deals with the values that have significance to the people affected by the decision. Wathern (1988:5) points out that, while useful, the distinction between magnitude and significance in EIA is not always valid, since the two elements are inextricably linked by the need for information to pass between them. Fuggle (1992:763) also cautions against viewing EIA in the same light as empirical research that results in scientific publication, since the objective is to allow informed judgement on the part of decision-makers and not to discover facts new to science.

Nevertheless, recurring criticism of the over-emphasis on procedural compliance is found in the literature. Atkins (1984:250) uses the terms "*functional aspects*" and "*structural aspects*" of an EIA, to differentiate between the elements of science and art respectively, and confirms that the "*structural aspects*" of procedure and decision-making have received most attention. Fairfax (1978, cited in Wathern, 1988:27) refers to the lack of procedural compliance as a frequent argument of environmental pressure groups opposing proposed developments in the USA. In a more recent paper, Brown and Hill (1995:225) refer specifically to a limitation in the South African IEM procedure, in their criticism of procedural compliance, in the form of non-integrated and stand-alone EIRs hindering a more active role for EIA.

In summary, the perceived problem that EIA is not effectively applied is evident in the emphasis on procedural compliance over technical or scientific rigour. To address the perceived problem, the study sets out to determine whether a generally applicable scheme of EIA methods for the routing of high voltage overhead electrical transmission lines is in use in South Africa. In the event of this not being the case, the study moves from the sectoral level of EIA to the project level, i.e. from the theory of generic, sectoral EIA methods that deal with linear developments, to the practice of applying EIA to the particular environmental impacts that result from high voltage overhead transmission line routing projects. It is at the project level of EIA that it is possible to gain a qualitative understanding of how effectively the known environmental impacts of particular projects are addressed. In this way, determining the validity of the technical content of the EIAs of high voltage overhead transmission line routing becomes possible.

2.3. SCOPE OF THE STUDY

This study addresses EIA methods as they apply to a subset of the transportation sector, namely the effectiveness of that category of methods used for routing high voltage overhead transmission lines. To properly understand the scope of the study, however, it is necessary to first gain a broader perspective of EIA theory. The initial literature review described in section 2.1. above also allows for this, by providing insight into the activities that generally comprise EIA. This section identifies and describes certain of these activities which form the focus of this study.

The works of Munn (1979:30-38), Bisset (1984:196-197) and Fuggle (1992:766-767) have been examined in order to establish the generally accepted activities required by EIA. These are provided in Table 1.

TABLE 1.

Munn, 1979	Bisset, 1984	Fuggle, 1992
identification	identification	data collection
prediction	measurement	analysis & interpretation
interpretation	interpretation	identification
communication	communication	communication
inspection	monitoring	

Table 1. EIA activities encountered in the initial literature review.

Of note in Table 1 is the sequential nature of the EIA activities prescribed in the literature, where EIA provides a means to an end. This was typical of EIA in the 1970's. A far more process-oriented approach has developed in the 1990's, with the integration of EIA within all the stages of the development project being seen as more important than an exercise that results in a stand-alone EIR. A multi-objective approach to EIA is now developing and Brown and Hill (1995:223-224) list the objectives as the provision of information, the mitigation of effects, the ensuring of public participation, the reinforcing of accountability, the environmental education of proponents and the influencing of planning and design. Some of these objectives cannot be compared with the sequential activities listed in Table 1, since they describe a different dimension of EIA. However, by incorporating the objectives suggested by Brown and Hill (1995:223-224), it has been possible to expand the list of activities in Table 1 and so provide a valid point of reference in defining the scope of this study.

For the purposes of this study, the following are considered to comprehensively address the activities required by EIA:

- Identification of information required for the assessment; scoping; public participation.
- Measurement and collection of the information.
- Interpretation and prediction, influencing planning and design; evaluation of alternatives.
- Mitigation of effects; providing information; reinforcing accountability.
- Communication of the findings of the assessment.
- Monitoring of the subsequent actions; education.

The concepts of screening and scoping were frequently encountered in the initial literature review and are synonymous with EIA. These concepts need to be dealt

with in the context of the generally accepted EIA activities described above. Screening is a procedure by which the appropriate level of assessment is determined. Scoping refers to the procedure for narrowing the scope of an assessment, ensuring that the focus remains on the impacts that are actually significant. This study does not examine screening. However, an element of scoping is inherent in this study, in that the known environmental impacts of high voltage overhead transmission lines are specifically dealt with. This occurs when the study moves from the sectoral level of EIA methods, to the more detailed project level. The known forms of impact are derived from an examination of the literature pertaining to high voltage overhead transmission lines in particular. They are further discussed in 2.4. below and are examined again specifically in 3.3. and 3.5. below.

Tomlinson (1984:163-194) deals in some detail with screening and scoping but makes the important point that these activities overlap. Shopley and Fuggle (1984:28) also emphasise the complexity of all the interacting issues addressed during EIA, in their reference to the choice of methods needing to be appropriate to societal values and administrative constraints. It is thus important to acknowledge that the array of activities required by EIA are not discrete but form part of a continuum. The more interactive role presently being proposed (Brown and Hill, 1995), whereby the design process can be substantially influenced, emphasises the continuous iterations required by the EIA process, rather than its sequential aspect.

Based on the generally accepted activities required by EIA, as identified above, it is now possible to identify those which are to form the focus of this study.

This study examines the technical or scientific content of EIA methods as they apply to high voltage overhead transmission line impacts. The technical or

scientific content of EIAs should be provided by specialists in their particular fields. When referring to the elements of science and art having relevance to decision-making in the EIA process, first dealt with in section 2.2. above, "science" must be understood to be the product of specialist input. The focus of this study is on the treatment of information that results from specialist investigation of environmental impacts identified by scoping. The focus is particular to the interpretation of the information, to allow for prediction and mitigation of possible consequences. Stated differently, the study concentrates on how the information is dealt with once it has been collected, and not with the methods *per se* of identifying and collecting the information.

Another perspective on the scope of the study is provided by the differentiation between science and art in EIA, referred to initially under section 2.1. and again in section 2.2. above. Beanlands (1988:36) graphically illustrates the changing importance through time of the social values related to decision-making (the "art" component) on the one hand, and the technical, scientific foundation (provided by specialist investigation) upon which decisions are based on the other. Figure 1 is derived from this illustration and shows graphically the area, within the sequential process of EIA, that the present study addresses. Figure 1 appears on the next page.

It must be noted that the social values referred to in Figure 1 relate to the subjective value judgement inherent in decision-making, and not to the elements of social science that may be important to the project. The latter are dealt with as part of the scientific component, although the lack of integration of the natural and social sciences in EIA is a matter of concern, particularly in South Africa (Quinlan, 1993:106-110).

FIGURE 1.

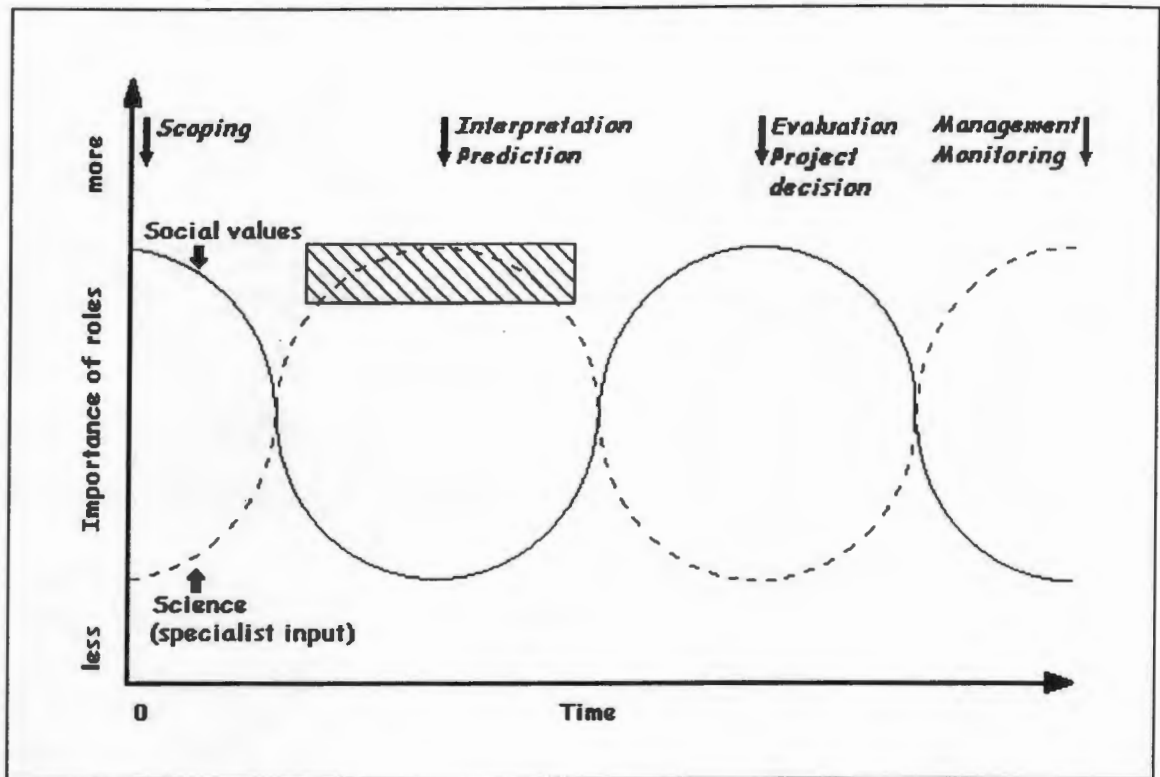


Figure 1. Graphic illustration of the focus of the study. The generic EIA tasks are shown in italics, while the shaded area indicates the focus of the study. Based on Beanlands' (1988:36) figure and adaptations by Hill (pers. comm.).

There is no geographic boundary to the theoretical stage of the study in Chapter 3, since it reviews published works on EIA theory from different parts of the world. Nor is time a constraint, since environmental assessment is a comparatively recent field of study. The application of the research procedure in Chapter 4, when the propositions stated in 2.5. below are addressed, is based on an examination of EIRs for high voltage overhead transmission line projects in South Africa since 1990, as well as two benchmark EIRs from developed countries (section 3.4.). The research excludes substations or other electrical installations.

A high voltage transmission line is defined as an electrical transmission line that carries a voltage greater than 30 000 volts.

The environmental impacts that result from transmission line projects differ in intensity and scale according to the phase in the life-cycle of the line. Impacts on the biophysical environment are more extreme during construction, while socio-economic impacts are more noticeable during the operational phase. However, this differentiation is not maintained in this study, since the focus is on how the technical information relevant to an EIA for a transmission line is interpreted and possible consequences predicted. All environmental impacts are dealt with collectively, acknowledging that their importance varies according to the phase of the transmission line project.

Given the research problem orientation, statistical analysis is not undertaken and the study comprises desk research rather than field work. It is also necessary to note that the study is restricted to EIA as it applies at the project level of sectoral development proposals and not to strategic issues like legislative proposals, policies, programmes or operational procedures. The hierarchy of strategic, sectoral and project EIA was described in section 2.1. above.

2.4. METHOD OF STUDY

The initial review already undertaken of the general literature underpinning EIA has allowed the research problem to be contextualised (sections 2.1.) and the perceived need for the study to be described (section 2.2.). The initial literature

review has also provided essential insight into the theoretical foundation of the study.

Hereafter, the main body of the study comprises several activities, grouped into the following stages:

- A detailed review of the literature on EIA methods, progressing from general EIA methods (section 3.1.), to linear EIA methods (section 3.2.). The findings are synthesised in Table 2.
- The identification of environmental impacts specific to high voltage overhead transmission lines (section 3.3.), and confirmation of the identification by means of two benchmark EIRs, i.e. standards against which others can be compared (section 3.4.). The findings are presented in Tables 5, 6 and 7.
- An examination of the two benchmark EIRs and six South African case study EIRs, to determine whether the EIA methods applied have a bearing on the synthesis, provided in Table 2, of generic EIA methods (section 4.2.).
- An examination of six South African case study EIRs, to determine whether the known environmental impacts that result from high voltage overhead transmission lines, provided in Tables 5, 6 and 7, are effectively dealt with (section 4.3.).
- A discussion of the propositions described in section 2.5. below (Chapter 5.), and reporting on the conclusions (Chapter 6.).

These stages in the study are now described more fully.

The detailed literature review begins with an examination of general EIA methods (section 3.1.), to ascertain whether any consistency exists among those that deal with utility corridor planning in particular. While it is necessary to begin with such a general examination of the variety of EIA methods used world wide, it is only the information that has relevance to the planning of utility corridors, i.e. linear EIA methods, that is distilled from this.

The literature on linear EIA methods is then examined in detail (section 3.2.). The intention is to determine whether high voltage overhead transmission line route selection is discernible as a specialised EIA method, within the body of information that deals with linear EIA methods.

Thereafter, the literature review focuses on the identification of the environmental impacts that result exclusively from overhead electrical transmission line projects (section 3.3.). This is at the sub-sectoral or project EIA level, since the available information relates to a specified type of development within the transportation sector.

To ensure that the information derived from the detailed literature review is comprehensive, two EIRs from North America are used as benchmark documents (section 3.4.). These are the Lennox - Hawthorne 500 kV project of Ontario Hydro in 1985 and the Clover - Carson 500 kV project of Virginia Power in 1992. Their selection criteria are also provided.

The sequential examination of the literature on EIA described in the preceding paragraphs, provides insights at two levels. Firstly, at the level of sectoral EIA methods as they are applied to linear developments. Secondly, at the project level, where the known forms of environmental impacts that result from high

voltage overhead transmission lines are identified. These insights provide the basis for the examination of the propositions provided in section 2.5.

Testing of the propositions is possible by the application of the research procedure described in Chapter 4, which relies on detailed analyses of case studies. The selection criteria for the six case studies used are described in detail in section 4.1. and the EIRs identified in this way are:

Kendal - Midas 400 kV, 1990

Muldersvlei - Stikland 400 kV, 1990

Hydra - Gamma 765 kV, 1992

Pegasus - Athene 400 kV, 1992

Ariadne - Hector 400 kV, 1994

Ariadne - Venus 400 kV, 1995.

The research procedure allows a qualitative picture to emerge of how well EIA practice in South Africa accords with the theory of linear EIA methods, and then addresses the question of the effectiveness of transmission line route selection. The concept of effectiveness is dealt with in section 2.5. After this analysis and discussion, the results of the study are written up and presented.

2.5. PROPOSITIONS

Before stating the propositions that justify the study, it is necessary to place the research approach in its appropriate scientific context.

There are essentially only two approaches to scientific investigation; inducing a universal premise from many particular observations, or deducing particular statements from a universal premise (Harvey, 1969:32).

The inductive approach requires numerous individual pieces of evidence, which, by analysis, lead the researcher to an intuitive generalisation. Analysis is understood as the interpretation of data in order to understand their relevance to some decision. Deductive reasoning, on the other hand, requires a major premise, based as it is on logical reasoning (Leedy, 1980:41-42).

In compiling the necessary theoretical framework for this study, no major premise is offered. Thus, deduction from the general to the specific is not possible and the study relies rather on an analytical inductive approach.

Thompson (1990:240) regards the evaluation of experience gained from applied EIA practice as a useful means of improving methods. The research method employed in the present study subscribes to this approach.

Since the study addresses the qualitative rather than quantitative contents of published works, the propositions are problem orientated rather than statistically orientated (Leedy, 1980:159-161). Adopting an inductive approach also allows the propositions to be put forward as statements for discussion, or research questions, rather than for the absolute testing of their validity.

The study is based on the assumption that the practice of EIA can be improved by a better understanding of the specialised technical aspects of EIA methods at both the sectoral and project levels. The first proposition addresses the theory of EIA, in terms of generic EIA methods at the sectoral level, while the second

proposition addresses the practice of EIA in South Africa, in terms of the known environmental impacts of high voltage overhead transmission lines at the project level.

The propositions being offered as statements for discussion in this study are therefore as follows:

PROPOSITION ONE

The EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives are specific for the purpose.

PROPOSITION TWO

The environmental impacts of high voltage overhead transmission lines are effectively addressed in the EIAs of power delivery projects in South Africa.

To determine whether the EIA methods that are applied in the routing of high voltage overhead transmission lines are specific for the particular purpose, as hypothesised in Proposition One, a synthesis of the literature on EIA methods is presented. From this synthesis, the information pertaining to linear developments generally, and high voltage overhead transmission lines in particular, is compared with the EIA methods used in two benchmark EIAs and an array of six South African case study EIAs.

The criterion used to determine the concept of effectiveness as it is used in Proposition Two, is the degree to which an impact that is recognised as significant forms part of the environmental evaluation. Impacts may be positive or negative but are generally perceived as the latter. The evaluation may comprise trade-offs between alternative routes or engineering design options, or mitigatory actions to minimise unavoidable adverse effects. The latter may be achieved by the redesigning of engineering hardware, the protection and rehabilitation of biophysical elements, or the protection and restoration of cultural elements.

This chapter has contextualised the perceived problem, provided it in a synoptic statement, described the scope and method of study, and stated the propositions for examination. The next chapter reviews the literature on EIA methods generally and the environmental impacts of high voltage overhead transmission lines in particular.

3.1. OVERVIEW OF LITERATURE ON EIA METHODS

The setting for this study, in terms of the shortcomings and activities in the EIA process, has been provided by the initial review of the EIA literature as described in sections 2.1. and 2.3. above. This section deals with EIA methods at a general level, to establish the foundation for the subsequent focus in the next section on EIA methods for linear development proposals in particular.

Numerous authors have examined the methods employed in EIA since its emergence as a distinct activity more than two decades ago. However, the intention here is not to provide a comprehensive review of as wide an array of published works as possible. Rather, a synthesis of relevant comparative studies of EIA methods is offered.

The works of Munn (1979), Bisset (1980), the Ministerie van Volksgezondheid en Milieuhygiene (1981), Atkins (1984), Shopley and Fuggle (1984), Wathern (1984), Beanlands (1988), Thompson (1990) and Fuggle (1992) are representative of the comparative reviews of EIA methods that have been undertaken. Such reviews usually employ a set of comparative criteria. Typically, the criteria have a bearing on the following three approaches:

- Reviews based on the utility of EIA methods.

- Reviews based on the ordered classification of EIA methods.
- Reviews based on a specific element, application or subset of EIA methods.

The discussion that follows deals with each of these three review approaches. Thereafter, a tabulated synthesis of EIA methods is presented (Table 2), which provides continuity with the next section (3.2.) of the literature review that focuses on EIA methods for linear development proposals in particular. For the sake of clarity and to avoid repetition and disparity, a brief description of the key features of each method is also provided in Table 2, rather than in the text.

3.1.1. Reviews based on the utility of EIA methods:

The utility of an EIA method is understood to refer to how well it satisfies the particular need for which it is applied. The works by Munn (1979), Bisset (1980) and Atkins (1984) are representative of reviews based on the utility of EIA methods.

Munn's (1979:30-38) survey is arranged around the five activities required to carry out an EIA. These are referred to in section 2.3. above and comprise identification, prediction, interpretation, communication and inspection. Methods for identification are listed as checklists, matrices, flow diagrams and overlays. For prediction, the difficulty of categorisation is acknowledged and a listing of methods is discouraged. The display of indicator values, ranking of grouped alternatives and numerical weighting methods are given as interpretation methods. An array of 24 communication methods not exclusive to EIA is provided. Inspection methods are simply tailored to be appropriate to deal with earlier predictions of effects and impacts.

Bisset (1980:28) also uses generally accepted utility criteria in his examination of EIA methods, corresponding to Munn's (1979:28) work but with the tasks having slightly different nomenclature. Bisset lists impact identification, measurement of effects, interpretation, communication and monitoring, while Munn refers to identification, prediction, interpretation, communication and inspection. The similarities are clear. Bisset (1980) does not, however, provide a tabulated or graphic comparison, but simply a text description. Relating Bisset's utility criteria to the methods under review in his work is thus difficult. Nevertheless, the four methods reviewed are: the extended Component Interaction Matrix (CIM), a refinement of the Leopold matrix undertaken by Environment Canada (Ross, 1976, cited in Bisset, 1980:29-30); systems diagrams, another application of the matrix approach, based on ecological systematics and developed by Sorensen (Bisset, 1980:32-33) as the network approach; quantitative methods, described by Bisset (1980:34-37) as including the Water Resources Assessment Methodology (WRAM), decision analysis and the Sondheim method; and ecosystem simulation modelling (Bisset, 1980:38-40), as advocated by Holling and Munn.

Atkins (1984:241-242) analyses utility by assessing the capability of six methods to meet 15 criteria derived from a review of environmental literature. Although this array of criteria is broader than those used by the previous two authors, a common thread is discernible in the recurring themes of identification, measurement, interpretation, prediction, communication and monitoring. The six methods that Atkins (1984:243-245) deals with are the McHarg overlay approach, the Leopold matrix, Dee's Battelle Environmental Evaluation System (EES), Sorensen's matrix-network, Adaptive Environmental Assessment and Management (AEAM) proposed by Holling, and the PADC Manual.

3.1.2. Reviews based on the ordered classification of EIA methods:

The ordered classifications of EIA methods is an approach that employs their being organised into categories or groups, according to some commonality in the characteristics of the methods. The works by the Ministerie van Volksgezondheid en Milieuhygiene (1981), Shopley and Fuggle (1984) and Fuggle (1992) are examples of such reviews.

The Ministerie van Volksgezondheid en Milieuhygiene (1981:42-43) examines 29 methods which are classified into three groups, namely, those that provide general guidance, those that allow for a structured, quantitative classification of methods and those developed for planning purposes. A complete list of the methods dealt with in this work, some of which are not often encountered in the literature, is not provided in this study. Rather, the most representative of the three given categories, as well as those that may be of particular significance, are examined. Methods that give general guidance include the PADC Manual approach to the assessment of major development proposals and The Standing Committee on Trunk Road Assessment's appraisal framework. The structured quantitative approach is represented by the Battelle EES, Odum's optimum pathway matrix and the Sondheim method. Planning functions are served by overlay mapping and cost-benefit techniques (Ministerie van Volksgezondheid en Milieuhygiene, 1981).

Shopley and Fuggle (1984:29-45) provide a comprehensive review, based on the following eight ordered categories: ad hoc approaches; checklists which include simple descriptions and more complex weight-scaling such as the EES; matrices of either presentational or mathematical character, with Leopold and the CIM being representative; networks like Sorensen's and Odum's; cartographic

overlay techniques; modelling procedures; evaluation techniques such as the Delphi approach; and adaptive methods like the AEAM.

The survey by Fuggle (1992:767-771) has three classifications: checklist and matrix methods, in the latter the Leopold approach being mentioned in particular; overlay and mapping methods which include McHarg and Geographical Information System (GIS) approaches; and panel evaluation derived from the Delphi technique, namely the Battelle EES approach. Two methods applicable for use in South Africa are also described (Fuggle, 1992:771-779). These are cross-tabulation and environmental mapping, developed from the matrix and overlay approaches respectively.

3.1.3. Reviews based on a specific element, application or subset of EIA methods:

A common approach to the review of EIA methods is the examination of specific elements, applications or subsets, these being issues such as significance of impacts, screening, scoping, direct impacts, indirect impacts, etc. The works by Wathern (1984), Beanlands (1988) and Thompson (1990) are used as examples.

Wathern (1984:215-223) addresses indirect impacts, i.e. those impacts that occur in environmental components remote from where the effects are felt directly. Methods for dealing with these are given as a modified CIM requiring multiplication of the components, and flow diagrams and network analysis which are believed to show indirect relationships between components.

Scoping methods, i.e. the process of identifying the important environmental issues, are examined by Beanlands (1988:37-38). A direct approach may be used

via meetings of all affected parties, formal hearings or submissions to an assessment panel. Indirect methods entail the distribution of questionnaires and the undertaking of surveys. Since these are essentially means of communication and are not exclusive to EIA, they are not dealt with further in this study.

Thompson (1990:236-239) focuses his review of EIA methods on their treatment of significance, i.e. the cost to society of a predicted impact. This is achieved by grouping 24 methods into a continuum of six categories. Representative of these are Solomon's WRAM, Sondheim's method, the PADC Manual approach, Leopold's matrix, the Fisher and Davies approach and Sorensen's framework.

3.1.4. Synthesis of EIA methods:

A discernible feature that emerges from the literature reviewed is the proliferation of EIA methods that developed in the USA in the decade that followed the promulgation of the National Environmental Policy Act in 1969. This is confirmed in Bisset's (1980:27-28) observations, which also include reference to the shift to numerical intricacy in the more recent methods.

The following table (Table 2) is a synthesis of the EIA methods identified above. Although it simply lists alphabetically the EIA methods encountered in the literature, an indication is also provided of whether or not an EIA method is specified for use in linear development proposals in particular, or whether the method is suitable for all types of projects. To determine this, the text of the literature reviewed earlier in this section was examined for any references that made specific note of the applicability of a particular method. Where no reference to linear development proposals is made in the description of a method, it is recorded as negative in Table 2. Specific application of a method to linear

development proposals is recorded as positive, while several that are indicated as being suitable for different types of projects are recorded as *inter alia*. This last-mentioned category was identified in the literature by terms such as "*..designed for the assessment of impacts associated with almost any type of construction project.*" (Munn, 1979:39) and "*..methodology easily adapted for any type of project.*" (Thompson, 1990:242).

Table 2 also provides brief descriptions of each of the EIA methods encountered in the literature. Including these descriptions in the table, in the form of the key features of each EIA method, and not in the text, provides better clarity, since reference to methods is derived from various literature sources. The sources were cited early in this section and comprised Munn (1979), Bisset (1980), the Ministerie van Volksgezondheid en Milieuhygiene (1981), Atkins (1984), Shopley and Fuggle (1984), Wathern (1984), Beanlands (1988), Thompson (1990) and Fuggle (1992). Providing a descriptive table avoids repetitious and disparate reference to the material that was examined. A more detailed description of EIA methods is not inimical to the objective of this stage of the study, which is to identify those methods that are specified for use in linear development proposals.

Table 2 follows on the next four pages.

TABLE 2.

METHOD	BRIEF DESCRIPTION OF METHOD	SPECIFIED FOR LINEAR USE?
Battelle EES	Quantitative, uses index of environmental quality, panel technique.	No
CIM	Refinement of Leopold's matrix, sophisticated multiplication technique borrowed from Sorenson.	No
Cost-benefit analysis	Gains and losses discounted to single representative figure, to identify alternative with greatest net benefit.	<i>Inter alia</i>
Cross tabulation	Development of Leopold's matrix, having several potential impacts evaluated in each cell.	No
Decision analysis	Emphasises multiple objectives, magnitude of impacts predicted by mathematical manipulation.	No

Table 2. Synthesis of EIA methods encountered in the literature reviewed. Where a method is stated as suitable for all types of projects, it is referred to as *inter alia*.

TABLE 2. (continued)

METHOD	BRIEF DESCRIPTION OF METHOD	SPECIFIED FOR LINEAR USE?
Delphi panel technique	Iterative feedback of expert opinion gained remotely, allows consensus on contentious issues.	No
Ecosystem simulation modelling	Complex models that predict changes in entire ecosystems, attempts to influence early design stage.	No
Environmental mapping	Development of the overlay mapping approach but using computer-based GIS.	Yes
Fisher and Davies approach	Phased process by multi- disciplinary team results in indicator of significance and decision matrix.	<i>Inter alia</i>
Holling's AEAM	Workshop-based matrices aimed at influencing pre-design stage of differing projects, ecosystem simulation modelling.	No

Table 2. (continued) Synthesis of EIA methods encountered in the literature reviewed. Where a method is stated as suitable for all types of projects, it is referred to as *inter alia*.

TABLE 2. (continued)

METHOD	BRIEF DESCRIPTION OF METHOD	SPECIFIED FOR LINEAR USE?
Leopold's matrix	Cross tabulation of two checklists, providing scaled rating of magnitude and significance of impacts.	<i>Inter alia</i>
Odum's optimum pathway matrix	Free format network diagrams, showing energy transfer in quantifiable units.	No
McHarg overlay mapping approach	Visual evaluation by aggregation of transparencies, spatial patterns show suitability for development.	Yes
PADC manual	Checklist- and matrix-based approach focused on information acquisition and impact identification and appraisal.	No

Table 2. (continued) Synthesis of EIA methods encountered in the literature reviewed. Where a method is stated as suitable for all types of projects, it is referred to as *inter alia*.

TABLE 2. (continued)

METHOD	BRIEF DESCRIPTION OF METHOD	SPECIFIED FOR LINEAR USE?
Solomon's WRAM	Based on checklist of weighted environmental, economic and social factors similar to EES, adaptable to local requirements.	No
Sondheim's method	Panel technique, impacts are rated and weighted into matrices which are further manipulated numerically to give total score for alternatives.	<i>Inter alia</i>
Sorensen's network analysis	Matrix that links first- and higher-order ecological impacts, provides visual analysis.	<i>Inter alia</i>
Trunk road framework	Inclusive range of effects, tabulated to allow interest groups to compare options.	Yes

Table 2. (continued) Synthesis of EIA methods encountered in the literature reviewed. Where a method is stated as suitable for all types of projects, it is referred to as *inter alia*.

Two of the EIA methods listed in Table 2, namely ecosystem simulation modelling and Odum's optimum pathway matrix, need to be recognised as methods that are

designed specifically for evaluating the ecological aspects of development proposals. They are not generally applicable EIA methods. However, since neither are specified for linear EIA use, their presence in the table does not hinder the further development of this study.

Of most significance in Table 2 is the apparent fact that only those EIA methods intentionally developed for linear development proposals, are exclusively suited for such applications. The validity of this statement is further examined in the next section, which deals with the specific category of linear EIA methods.

3.2. REVIEW OF LITERATURE ON LINEAR EIA METHODS

The previous section (3.1.) provided an overview of EIA methods, to determine the extent to which linear development proposals like utility corridors are dealt with at a general level. Of the 18 EIA methods located in the literature reviewed, five were stated by the authors to be adaptable to various types of developments and three others to be specified for linear development proposals.

However, it is known that one of the EIA methods specified for linear developments, namely the trunk road framework, has been applied in non-linear projects (Hill, pers. comm.). It must also be acknowledged that EIA methods described in Table 2 as not being suitable for linear developments, could in fact be used for linear developments. The intention of this stage of the study, however, is to discern commonality in the literature that underpins EIA methods generally, and not to find discrepancies in the application of particular methods.

Table 2 is therefore regarded as a valid reflection of the status of EIA methods originally devised for linear developments.

The five EIA methods which were stated to be adaptable to various types of developments are categorised as *inter alia* in Table 2. The criterion used to determine this categorisation was whether specific mention was made in the text of the literature reviewed, of the applicability of an EIA method for different types of development proposals. Cost-benefit analysis (Jones *et al*, 1990:97-98), the Fisher and Davies approach (Fisher and Davies, 1973), Leopold's matrix (Leopold *et al*, 1971), Sondheim's method (Sondheim, 1978) and Sorensen's network analysis (Sorensen, 1971) fall into this category and are now discussed.

Cost-benefit analysis derives from the discipline of economics and has been in use since before EIA became established (Wathern, 1988:21). The objective of cost-benefit analysis is to ensure that the development costs of a project are exceeded by the economic benefit that results. A more contemporary application is where environmental, societal or other costs are compared with the relevant benefits that would derive from a development proposal. Cost-benefit analysis clearly provides a useful means of assessing development proposals but has no significant advantage as an EIA method, that would warrant its being regarded as having particular relevance to linear EIA.

The Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis all utilise some form of checklist or matrix. Checklist and matrix EIA methods are among the earlier methods to be developed and the four being examined date from 1973, 1971, 1978 and 1971 respectively. The two methods of checklists and matrices are treated together in this section of the study, since a matrix must of necessity contain a checklist - usually two checklists arranged on perpendicular axes, allowing for comparison of

the physical actions required by a development proposal, against the effect on the environmental components present in the area in question.

Checklist and matrix EIA methods are necessarily comprehensive, based as they are on structured lists of questions, and provide a visual display of the most serious environmental impacts that may be expected (Fuggle, 1992:769). However, it is this comprehensiveness that detracts from their effectiveness for linear EIA applications in particular. A separate matrix is required for each development proposal alternative, whether these are alternative sites, alternative mitigatory measures, alternative time frames for construction or operation, alternative technologies, etc., or for sequential stages in numerical manipulation such as those used in the Sondheim method. It is self-evident that the application of the matrix method of EIA can become very complex. When applied to linear development proposals containing alternative routes, however, this complexity increases considerably, since additional matrices are required for each alternative route or combination of routes, as well as individual sections of routes that form differentiated units, such as landscapes, veldtypes, landuse types, etc. Although Fuggle (1992:767) is of the opinion that checklists and matrices are the most commonly used EIA methods, more recent methods tend towards less complexity. This is in keeping with EIA becoming part of political and decision-making processes, where qualitative information that can contribute to substantive decision-making, is favoured (Bisset, 1980:40-41; Ortolano and Shepherd, 1995:4). Checklist and matrix EIA methods appear not to have any outstanding value as linear EIA methods.

However, the five EIA methods regarded as being adaptable to different types of developments, namely cost-benefit analysis, the Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis, cannot be disregarded for the rest of this study. Since the indication in Table 2 of the

suitability of particular methods for linear development proposals was not rigorous enough to reject these methods, the benchmark and case study EIRs will first be examined. Thereafter, a better-informed decision as to the relevancy of these five EIA methods is possible in the discussion in Chapter 5, when Proposition One as stated in section 2.5. is addressed.

The three methods identified in Table 2 that are specified for linear development proposals are environmental mapping, the McHarg overlay mapping approach and the trunk road framework. These actually comprise only two discernible methods, namely the environmental or overlay mapping approach (Fuggle, 1992:776-779; McHarg, 1969:31-41) and the framework approach (Advisory Committee on Trunk Road Assessment, 1979).

From the above, it appears that at the level of general EIA methods, little attention has been paid to linear developments in particular. Although Ortolano and Shepherd (1995:7) caution against the development of a single, universally applicable EIA method, transportation activities are recognised by the World Bank (1995:15) as comprising a distinct sector of development. The paucity of attention to linear development proposals in the overview of literature on EIA methods is thus significant. It also indicates a need for a more focused review of the literature. It was therefore necessary to search the literature specifically for linear EIA methods, rather than to locate these by means of the general review reported in section 3.1. Information technology was used to do this.

An electronic search, tradenamed "Dialog", of a selection of the bibliographic databases accessible by computer network to suitably equipped academic libraries world-wide, was undertaken (Dialog Information Services, Palo Alto, CA 94304, USA). The criteria specified in the query commands comprised the following (Table 3), at three sequential levels in the search:

TABLE 3.

First level	Second level	Third level
environmental	assessment	linear
socio-economic development	appraisal	ribbon
	evaluation	utilities
	criteria	corridors
	factors	transmission lines
	method	highways
	statement	roads
	decision making	freeways
		railroads
		pipelines

Table 3. The query criteria used in the electronic search of bibliographic databases.

The bibliographic database search produced 65 references, of which nine dealt with linear developments generally and 56 with specific types of linear development like roads, transmission lines, railways and pipelines. The references dealing with specific types of linear development are examined in more detail in section 3.3. below.

The abstracts of the nine references that dealt with linear developments generally, were scrutinised. It was found that three (Dooley, 1976; Lenco, 1985; Vitale and Galbraith, 1990) are electronic methods akin to environmental or overlay mapping in that they make use of satellite remote sensing, mathematically manipulated computer graphics or computer-aided design, to produce visual representations of information. The remaining six references (Beeman and

Schreiber, 1976; Smith, 1976a; Smith, 1976b; Stein, 1977; Wester and Weeter, 1977; McCarthy and Thurler, 1991) describe manual methods that identify, synthesise or tabulate information, in the form of guidelines or schematic presentations.

Of note is that the methods identified by the bibliographic database search all fall into one of the two methods already discerned in section 3.1. and described at the beginning of this section. These comprise the various overlay mapping methods, and methods that employ some form of framework or tabulation of information.

Overlay mapping has developed from a manual cartographic approach (McHarg, 1969:31-41; US Dept of Agriculture, 1975:1-147), to modern GIS computer applications (Sankoh *et al*, 1993:323-334). Non-cartographic methods usually based on some form of tabulation, have emerged in Canada (Environment and Land Use Committee, 1977) and in the United Kingdom (Advisory Committee on Trunk Road Assessment, 1979).

It is necessary to acknowledge that EIA is used for a wide variety of applications, where both direct and indirect impacts of varying intensities, over divergent geographical areas, may occur. Thompson (1990:248) makes the point that finding a standard EIA method is less critical than a proper understanding of the characteristics of the particular project and how it interacts with the environment. This less rigid view of EIA is reflected in the contemporary approach that is emerging, where emphasis is being placed on the multiple objectives that should be strived for (Brown and Hill, 1995) and the integration of EIA with other elements of development projects (Ortolano and Shepherd, 1995:27).

In summary of the review of the literature on linear EIA methods, it would appear that the question whether to approach linear development proposals as series of site-specific EIAs, or as amalgams of different sites, has not been resolved. Indications from the information gained from this section, and following from section 3.1., are that EIAs for linear development proposals usually comprise either overlay mapping methods or tabulation methods, or both. Whether the five EIA methods regarded as being adaptable to different types of developments (referred to as *inter alia* in Table 2), namely cost-benefit analysis, the Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis, have any bearing on linear development proposals, will be ascertained after the benchmark and case study EIRs have been examined. No other linear EIA methods were encountered that were specified for high voltage overhead transmission line route selection exclusively.

The next section examines the literature pertaining to EIA for high voltage overhead transmission line development proposals in particular. Since no EIA methods are specified exclusively for this purpose, it is also at this point in the study that the emphasis shifts from the sectoral level of EIA methods, i.e. linear EIA methods in the transportation sector, to the lower and more detailed level of project or sub-sectoral environmental impacts specific to the particular type of development, i.e. high voltage overhead transmission lines.

3.3. REVIEW OF LITERATURE ON THE ENVIRONMENTAL IMPACTS OF HIGH VOLTAGE OVERHEAD TRANSMISSION LINES

The previous section (3.2.) examined the extent to which EIA methods for linear development proposals have become discernible in the literature, and whether any of these are specified for high voltage overhead transmission line route selection in particular. It is apparent that overlay mapping and tabulation are the only two categories of specialised linear EIA methods to have developed. Both are frequently used for transmission line development proposals, but not exclusively. There are various forms of overlay mapping and tabulation, with both methods making use of information technology to a greater or lesser extent.

The objective of the literature search has been to sequentially review the literature on EIA methods, from a general level (section 3.1.), to the level of linear development proposals within the transportation sector (section 3.2.), culminating in this section which deals with the sub-sectoral or project EIA level of high voltage overhead transmission lines. Given that no EIA method is specified at this level, the approach is rather to identify the forms of environmental impact known to result from transmission lines. When applying the research procedure for this study (Chapter 4), these known impacts are examined in terms of how effectively they are dealt with in an array of case studies. Sections 2.4. and 2.5. above provided detail about how this is achieved.

To isolate the body of literature from which the known forms of environmental impact resulting from high voltage overhead transmission lines can be distilled, the information from the electronic search of the "Dialog" bibliographic databases (section 3.2. and Table 3) was revisited.

Of the 65 references located, nine relate to linear EIA in general. These were dealt with in section 3.2. Of the remaining 56 references, the distribution per type of linear development is given in the following table:

TABLE 4.

Type of linear development	Number	Percentage
Transmission lines	26	46
Roads and highways	19	35
Pipelines	8	8
Railways	3	3
Total	56	100

Table 4. The distribution of references located by means of the "Dialog" electronic bibliography search, per type of linear development.

Of note in Table 4 is that almost half of the references located deal with transmission lines, with roads and highways making up the bulk of the balance. However, this predominance of attention to transmission lines is not reflected in other bibliographic sources. For instance, Roe *et al* (1995:43, 66-68) list two transmission line references, five road references, one railway reference and three that deal with both roads and railways, in their directory of EIA guidelines world-wide. Also, the United Nations (1994:5-11) makes no specific reference to transmission lines in their examination of trends in the EIAs of energy projects. The references located in the "Dialog" electronic bibliography search were therefore supplemented by additional relevant material encountered during the other, non-electronic, literature searches that form part of this study.

With these sources of information now available, the environmental impacts that result from the installation and operation of high voltage overhead transmission lines are identified. These may be characterised as first-order impacts (e.g. habitat destruction) or higher-order impacts (e.g. alien vegetation infestation following habitat destruction) and as spatial (the physical magnitude of the impact) or temporal (e.g. impacts felt mainly during the construction phase of a transmission line). As indicated in section 2.3. above, the impacts are dealt with collectively. Although their importance varies at different phases of the life of a transmission line, e.g. construction, operation and decommissioning, this is not inimical to this study. Transmission lines are less disturbing to the biological and physical resource base than most other types of linear developments (Thorsell, 1976:6), because direct habitat destruction is unavoidable only at transmission line towers.

The literature examined in the identification of environmental impacts that are known to result from high voltage overhead transmission lines, comprise the following: Denbrock (1973), US Dept of Agriculture (1975), de Waal Malefyt *et al* (1976), Giles *et al* (1976), Howlett (1976), Pangburn and Wahlquist (1976), Smith (1976b), Thorsell (1976), US Dept of Energy (1979), Andersen (1981), Evans (1981), Saotome *et al* (1981), Sarofim (1981), Scott (1981), Sharma and Sharma (1981), Thorpe (1981), Monbailliu (1984), Scherer *et al* (1984), CIGRE (1986), Rumsey (1986), Lawson and Wyndham (1992), United Nations (1994), Roe *et al* (1995), American Physical Society (1995). Because the variety of impacts is wide and because they were identified at a detailed level, individual reference citation is not provided in the text that follows. Multiple references to the same impact, and numerous impacts contained in single references, mitigate against providing individual citations. The works listed earlier in this paragraph collectively provided the detailed information that makes up the rest of this section.

The environmental impacts that are known to result from high voltage overhead transmission lines are now described, under the groupings of biophysical impacts, socio-economic impacts and electrotechnical impacts. This grouping of impacts is often encountered in EIRs.

3.3.1. Biophysical impacts:

Vegetation has a controlling influence over the species composition of fauna in a given habitat. In striving to maintain biotic diversity, which is one of the basic principles of global conservation strategies, this interaction between plants and animals must be respected. The biophysical impacts that result from high voltage overhead transmission lines comprise the following three categories: faunal impacts, floral impacts and physical impacts.

(a) Faunal impacts

Injury or mortality often result from interactions between animals and the transmission line structures. Transmission line structures collectively refer to the towers and conductors that make up high voltage overhead lines. Interaction with such structures poses a very real threat to some populations of rare or endangered bird species. The cranes (family *Gruidae*) and larger raptors are cases in point in South Africa. Interaction is usually in the form of collision with transmission line conductors, although electrocution at towers also occurs. Not only wild birds are at risk. Primates and domestic animals and birds are also known to come into contact with transmission line structures. Any rare or endangered species of wildlife likely to occur in, or migrate through, a transmission line corridor should be identified and protected, to ensure that the

diversity of wildlife in the area is maintained. A variety of mitigatory measures are available, such as insulation and line marking, and animal interactions can usually be significantly reduced by application of these measures.

It must be noted that the impacts that result from animal interactions with transmission lines are not only of ecological significance. Animal interactions often result in outages, i.e. temporary disconnections, of the electricity supply and this has significance for the business performance of the electricity company concerned. Contamination of insulators by the faeces from birds nesting, roosting or perching on transmission line towers, increases the risk of flashovers that result in outages. However, the greatest proportion of electricity supply loss often results from interactions with less rare but numerically more abundant species like crows (family Corvidae).

Transmission lines can impact on wildlife for considerable periods of time. A servitude through a forest, for instance, will require vegetation being kept cleared for the operational life of the transmission line, making the habitat unavailable for wildlife. Servitudes also allow easier access by humans, which has been known to increase wildlife exposure to hunting, whether legally or not.

(b) Floral impacts

The operation of a transmission line often requires a permanent change to the vegetation found in the corridor that the powerline occupies. The exceptions to this are where the particular land use or habitat are such that vegetation is either non-existent or of low growth height. The critical factor is the clearance distance required between transmission line structures and surrounding vegetation, to allow for adequate electrical insulation. The technical perspective

on this is discussed further under sub-section 3.3.3.(b) below, but the implication for surrounding vegetation is that it often needs to be manipulated in some way. Tall towers and long spans between towers can reduce the amount of manipulation, particularly in broken terrain, because greater clearances are achieved.

The effect of changes to vegetation may result in a first-order impact, where the vegetation itself has an inherent value, due to its ecological significance as a threatened or rare habitat, for instance. Higher-order impacts may result from the manipulation of vegetation to the point where it is removed or replaced entirely. This has ecological implications such as alien vegetation infestation, as well as the spread of plant diseases, by the transport of seed-contaminated mud adhering to mechanised equipment, for instance. There are also economic implications where the vegetation in question may have agricultural or silvicultural value.

Other potential impacts to vegetation are the misuse of herbicides and unacceptable means of disposal of debris cleared from the transmission line corridor. There are also pollution and safety aspects to herbicide use and debris disposal.

Rehabilitation by reinstating disturbed vegetation and avoiding abrupt changes in the composition and height of plant species at servitude edges in forests, provide means of mitigation. Wind funnelling through apertures in vegetation curtains like wind breaks can damage crops or other vegetation.

(c) Physical impacts

Taking into account the vegetation changes described in sub-section 3.3.1.(b) above, it is clear that the soil surface occupied by a transmission line servitude may also be subjected to changes. The most important implication is the threat of soil erosion that can result from the exposure of the soil surface, or bedrock in extreme cases, due to vegetation removal, physical trampling or earth-moving. The requirement for vehicle access, during construction as well as operation of the transmission line, is often the cause of soil erosion. Characteristics of the terrain, such as the soil stability and angle of any slope that a transmission line crosses, are critical factors in route selection. Geological conditions influence the bearing capacity of foundations for transmission line towers, for instance.

Flood plains and river banks are sensitive to erosion and transmission line towers located in such areas increase the potential for environmental impact. Another threat to rivers from adjacent transmission lines is vegetation cleared from the servitude being discarded in the water. This can inhibit ecological processes, by increasing turbidity, for instance, and degrade stream quality. Areas where floods are a hazard need to be approached with caution when routing a transmission line. Increased sediment load of rivers and streams, resulting from activities associated with the installation and operation of transmission lines, has serious ecological consequences. Alterations to drainage patterns often result in environmental impacts. Large areas of water that cannot be crossed with a single span, should rather be skirted.

Weather conditions at certain times of the year exacerbate physical impacts and should be avoided, particularly during construction. A transmission line should not be constructed in mountainous terrain, for instance, during periods of high rainfall.

3.3.2. Socio-economic impacts:

The socio-economic impacts that result from the presence of transmission lines are categorised into land use impacts, visual impacts and stakeholder impacts.

(a) Land use impacts

At a regional level, land use constraints are usually the major determinant of a transmission line route. Existing as well as proposed future uses need to be considered, before a transmission line development proposal is initiated.

The land that a transmission line servitude occupies is restricted in terms of other uses to which the land may be made available. The restrictions vary according to the particular type of land use. Forestry land may see timber production lost, agricultural land may see crop production reduced and areas protected for nature conservation purposes may see natural habitats infringed. Mineral extraction in the form of mining, and aggregate production in the form of quarrying and borrow pits, may be seriously affected, while pasturage and other extensive forms of agricultural use are less restricted by the presence of transmission lines. Industrial and other areas where human development has been intensive, can also be less sensitive to transmission lines, while residential areas and architectural precincts, on the other hand, may pose particularly severe land use restrictions. Areas that enjoy some form of nature conservation status, as well as historic and archaeological sites and cultural resources are specifically sensitive and should be avoided. Institutional land use such as schools, churches and the military, also pose restrictions. Defence forces, for instance, frequently impose severe restrictions on their installations.

Impact on agricultural potential is an area that has seen considerable attention as far as the presence of high voltage overhead transmission lines is concerned. The most important issues that need to be addressed are historic trends and future projections in crop price, yield and rotation systems, aerial crop spraying requirements, restriction of pivot irrigation, soil compaction at transmission line towers and inhibition of fertiliser application resulting in weed accumulation. The nature and magnitude of impacts are crop-specific and effect either production or operation. The timing of transmission line activities should also not infringe important agricultural activities such as harvesting and planting.

The degree to which land use activities within transmission line servitudes are restricted, is related to the extent to which multiplicity of land usage is possible. The innovative use of transmission line servitudes for a variety of different purposes is becoming the norm. The provision of open space and recreation areas within servitudes is an example of a contemporary approach that has benefit for both the electricity company and the community. Multiple usage does, however, require a closer working relationship between the transmission line EIA practitioner and the regional land use planning profession. The corridor conservation concept, whereby various parties collaborate in the management of common utility corridors for the benefit of nature conservation, also depends on co-operation at a regional planning level.

The effects of transmission lines on local traffic patterns and transportation systems must be taken into account. The presence of airfields and aircraft flight paths are important, due to the risk of collisions, as are the location of road reserves and crossings of major highways, due to additional clearances being required. Bulky loads may need to be transported during construction and whether the existing roads can accommodate the particular types of vehicles, must be assessed.

Another important land use characteristic is the fabric of the landscape, or the stamp left on the environment by the patterns of boundaries that land tenure brings about. Matching the routing of high voltage overhead transmission lines with property boundaries, as well as locating the towers at the boundaries, is able to reduce land use impacts.

(b) Visual impacts

The visual obtrusiveness of transmission line structures is a major environmental impact, since it affects extensive areas and a wide array of people. The environmental impacts described in the rest of this section (3.3.) concern the corridor of land in the immediate vicinity of a transmission line, whereas the visual impacts may be discerned from much further afield. The effect on the various viewsheds, i.e. the spatial dimensions of particular vistas, that comprise the landscape through which a transmission line runs, should be assessed.

The evaluation of visual impacts can be either subjective or objective, depending on the composition of the team of observers and assessors (Monbailliu, 1984:265-271). The evaluation usually comprises an examination of landscape units, based on cartographic grid squares or tracts of homogenous relief or vegetation, according to numerous visual characteristics such as scale, texture, seasonal changes, visual dominance of elements, etc. The most important of these visual parameters, which are line, form, colour and texture, are dealt with in more detail in the following paragraphs.

Many old human structures appear to be appropriate to their surroundings. The function that has been provided over time by an old bridge built of local materials, for instance, lends it a sense of integration with the environment.

There is an identifiable compatibility with the landscape. Transmission lines built of new materials that originate outside the local context and using complex and evolving technology, are not easy to integrate with the landscape.

The visual parameters of line, form, colour and texture dictate how visible a transmission line will be in a particular landscape. Where these parameters of the transmission line are similar to those of the landscape, the contrast is lessened and better compatibility between transmission line and landscape results. Each of these visual parameters is now described.

Line in the landscape refers to ridges, roads, forest edges or any other linear feature prescribed by the landscape. A transmission line crossing an horizon is an extreme case of a line in the landscape being transgressed. Lines may be weak or strong, straight or curved, or vertical or horizontal. The same characteristics can apply to the presence of high voltage overhead transmission line structures, allowing for contrast with the landscape to be reduced. For instance, in an open, horizontal landscape, a tall, narrow transmission line tower presenting a vertical, strong visual characteristic, would be less compatible than a low, squat H-frame tower.

The form presented by the landscape results from the patterns of physical and vegetative features that are found and may be flat or broken, simple or complex, or bold or weak. Transmission line structures, particularly towers, may also be described in terms of the forms they present and compatibility results from achieving similarity between these and the landscape. The shape and size of a transmission line towers should approximate the surrounding landscape.

Colours in the foreground of a landscape are more distinct than those in the middleground, while background colours are the most muted. There are also

seasonal changes in the colours contained in a landscape. Transmission line structures may be brown wood, grey galvanised metal or purposefully rusted brown metal. In extreme cases, transmission line structures may be painted any chosen colour. Insulators may be glazed a brown colour and conductors may be chemically treated to reduce reflection. Reflection is regarded as more visually intrusive than colour. There are also changes to the colours in the landscape that result from changes to the vegetation and substrate within a transmission line servitude, as discussed in sub-sections 3.3.1.(b) and 3.3.1.(c). The greater the contrast between the colour of the transmission line structures and the colour of the landscape, the more visually obvious the line will be.

The combination of vegetation, soil, rock, water, and manmade changes to these, results in a landscape having a particular texture. A landscape that presents a varied texture is able to accommodate a transmission line more easily, since the line can remain visually subordinate to its natural or manmade surroundings. For instance, open, latticed transmission line towers, with their slender component parts, are more appropriate than solid structures in a landscape that displays an open texture.

Line, form, colour and texture provide visual parameters within which the compatibility between a transmission line and the surrounding landscape can be evaluated. Ultimately, however, the physical presence of a transmission line results from it either being absorbed by or inserted into a landscape. The absorption of a transmission line into a landscape refers to the limiting of its visual presence by utilising these four visual parameters to "hide" the line. Absorption is strived for in landscapes that are perceived as scenic or picturesque. Insertion, on the other hand, refers to the placing of transmission lines in landscapes that have undergone manmade changes. The intention is not to reduce the visual appearance of the transmission line, but rather to ensure that

it is appropriate to existing features in the landscape. Optimising on utility corridors, by combining transmission lines with existing roads and railways, is a typical case of insertion. A significant advantage to this approach is that access is usually available, reducing this impact during the most critical construction phase.

Where transmission lines cross roads or railways, adjacent vegetation may be left intact, to screen cleared servitudes from view. The principle of using vegetation, whether existing or planted, to camouflage transmission line structures, should always be borne in mind.

(c) Stakeholder impacts

Stakeholders may be directly affected, indirectly affected or have some statutory role. There are four groups of stakeholders that may, collectively or individually, be subjected to environmental impacts that result from electricity transmission lines. These are the supplier of electricity, the consumer of electricity, the landowner over whose property transmission lines are built, and the community.

The supplier may be any licensed electricity company, local authority or joint venture electricity company. The supplier is responsible for the source and provision of the electricity. However, this study is limited to the distribution of electricity through high voltage transmission lines of > 30 kV, and does not deal with the reticulation of electricity to the end user. For the purpose of this study, therefore, the impact on the supplier does not go beyond meeting statutory or self-imposed environmental obligations, which amounts to making the

resources available for EIAs of proposed transmission line projects to be carried out. The supplier is therefore not included in the tables presented in section 3.4. It is the consumer that establishes the need for the provision of electricity and agrees to purchase the product. Regional growth and industrial development contribute to increased demand for electricity. Consumers may be collections of individual households or individual bulk users like local authorities or large industries. Transmission lines distribute electricity in voltages greater than 30 kV and seldom directly to the end user. Therefore, the environmental concerns of individual electricity consumers, such as demand side management that promotes efficient and optimum use of electrical energy on the consumer's side of the electricity meter, are not as important as they are to bulk users of electricity. There are, however, economic implications for new consumers.

The landowner has to agree to the presence of a transmission line on his or her property. Note that the landowner need not be a private individual but may be a collective, a company or the State. It is at the level of the landowner that the issue of individual concerns conflicting with the common good of society comes into play. Achieving common good implies that some action results in a net benefit to society. Although common good usually prevails, it is the landowner that ultimately suffers most of the specific environmental impacts that result from the presence of electrical transmission lines. Route selection should result from collective and systematic EIA and should not comprise single purpose proposals, i.e. proposals not offering alternatives, that originate from outside the community. Negative impacts on the landowner comprise deprivation of a perceived freedom of tenureship, reduced property values and forced renunciation of property. Landowner impacts, in terms of the number of properties crossed by a proposed transmission line, is an important factor in deciding between alternative routes.

The environmental impacts of a transmission line on the community, go beyond those discussed in the rest of this section. The provision of electricity to a residential area, for instance, that previously did not have it, usually sees some economic growth in the community. Social impacts like changed consumer behaviour can result from increases in disposable income and the manner in which it is dealt with. Besides such socio-economic impacts, cultural resources can also suffer impacts and the value to the community of cultural elements in the landscape, whether built or natural, must be identified and respected. National monuments and heritage sites, archaeological sites and historic and architectural precincts fall into this category.

In cases where people are displaced and resettled elsewhere, to make way for transmission lines, the social, cultural and economic impacts can be extreme. In remote regions like areas of extensive agriculture, the way of life of people living on farms may be changed by the presence of transmission lines. During the construction of a transmission line, temporary camps are often provided for the workers when the community is unable to absorb an influx of people. Local entrepreneurs can benefit from providing services to such camps. However, since the skilled personnel required for the construction of transmission lines are usually imported, few skilled employment opportunities for local people are created. Given this mobility of skilled workers, local expenditure on goods and services is generally low and the multiplier effect is minimal and short-lived.

Society as a whole must benefit from the presence of a transmission line and issues of public health and safety must be addressed. An increase in public services like fire protection may be necessary and regulatory and local authorities have a responsibility in this regard. Effects on labour, housing, local industry and population distribution are all issues that need to be addressed in a co-operative fashion with all the interested and affected parties. Representative

groups in the form of Non-Governmental Organisations (NGOs) and Community Based Organisations (CBOs) often have environmental concerns as their *raison d'être* and consequently play a vital role in EIA.

3.3.3. Electrotechnical impacts:

The electrotechnical impacts that result from electricity transmission lines relate to the servitude, to clearance distances, to the electrical effects and to design implications. These are now described in more detail.

(a) The servitude

In the legal sense, the servitude, also known as the right of way or wayleave, is a right given to the transmission line operator by the owner or occupier of the affected land, which permits the operator to install, maintain and possibly expand a transmission line. It provides for the right of entry and passage within and onto public and private property. In a physical sense, the servitude is the space occupied by the transmission line corridor and, at ground level, the dimensions of the servitude are determined by the height, width and configuration of the circuits and conductors that comprise a particular line. Landowners with transmission line servitudes on their properties are usually compensated in some fashion. The width of the servitude is proportional to the voltage that the transmission line carries. Therefore, reducing the servitude width depends on optimising the load-carrying capability of the transmission line. This may be done at the design stage of a transmission line project, by employing structures that can support more than one circuit, by increasing the power transfer capability of

lines, by developing more compact structures and by optimising on existing utility corridors to reduce servitude width.

The amount of land that transmission line towers actually occupy comprises a scant one to two percent of the total servitude area (Pangburn and Wahlquist, 1976:51), although this is greater during the construction phase.

(b) Clearance distances

Sufficient separation between one conductor and the next and between conductors and the ground, is essential to ensure that flashovers do not occur. A flashover occurs when an electrical arc passes from one electrically charged object to another. The higher the transmission voltage, the greater these clearance distances need to be. Vertical clearance refers to the specified distance between the lowest conductor and the ground at the point at which conductor sag is at a maximum, while horizontal clearance refers to the minimum distance to adjacent buildings or trees during the strongest likely winds. Examples of prescribed clearance distances in South Africa are contained in an industry technical bulletin (Eskom, 1994b) and in the Occupational Health and Safety Act, Number 85 of 1993 (Republic of South Africa, 1993). Clearance over navigable water obviously needs to be much higher than over land.

The same design criteria for optimising the load-carrying capability of transmission lines referred to in sub-section 3.3.3.(a) above, are relevant to reducing the environmental impacts associated with clearance distances. These are the employment of double circuit structures, the increasing of the power transfer capability of lines, the development of more compact structures and optimising the use of an existing utility corridors by stacking circuits and thus reducing servitude width. Also, the edge of the cleared area can be made to fit

the contour of a swinging conductor, by undertaking less clearing at towers than in the areas adjacent to the conductor at the middle of the span between towers, where the displacement from the centre line is the greatest.

The issues of security and public safety are also important in terms of clearance distances between live conductors, and between live conductors and the ground. Transmission line towers are attractive to inquisitive children, for instance, and adequate clearance distances are vital.

(c) Electrical effects

The electrical effects that may result in environmental impacts comprise electric and magnetic fields, and corona effects.

The voltage carried by a transmission line creates an electric field, while the currents flowing through conductors cause a magnetic field. These fields are collectively known as electromagnetic fields, or EMFs. An object within an EMF may have a voltage and current induced within it and this is discharged on grounding. The effect on humans is not hazardous, is only of nuisance value and can be mitigated by grounding conductive objects in the vicinity of transmission lines. Concerns have also been expressed about cardiac pacemakers becoming unreliable in EMFs but these have been allayed by advances in electromagnetic technology.

The long term biological effects of exposure to EMFs has been a subject of intensive study for many years and no conclusive evidence of adverse effects on human health has been found (American Physical Society, 1995). Nevertheless, as a precautionary approach, human habitation is generally not allowed in the

immediate vicinity of transmission lines in South Africa. Induced voltage diminishes rapidly with distance though, and its magnitude is inversely proportional to the square of the separating distance. The strength of the EMF measured at the edge of the servitude appears also not to be significantly influenced by the height of the conductor.

Transmission line corona is caused by ionisation of air in the electric field around conductors. This results in audible noise, radio interference and the generation of ozone and nitrous oxide. Audible noise may be high enough to disturb humans and is the most serious of the environmental impacts caused by the corona effect. Radio interference may require avoiding telecommunications facilities or modifications to antennae in the proximity of high voltage overhead transmission lines, particularly in areas of low signal strength. The quantities of ozone and nitrous oxide produced by the corona effect are small enough not to warrant environmental concern. The ozone formed by transmission line corona, for instance, has a half life of approximately one hour.

(d) Design implications

Many of the environmental impacts that result from high voltage overhead transmission lines can be mitigated or avoided completely by sensitive planning during the design phase of the project. Such mitigation may be overt, as in routing a line away from visually sensitive areas, or subtle, as in reusing servitudes by upgrading conductors, insulators and towers, to meet new demands. Employing appropriate design criteria has advantages for electrotechnical, cost and operational aspects of power delivery projects.

Examples of design criteria relevant to the agricultural sector, for instance, relate to the timing of installation and operation of a transmission line, if these conflict with the crop production activities of planting and harvesting, or with particular weather conditions. The design of towers can also inhibit crop production if the area occupied by the towers is excessive. Towers within cultivated lands have more impact than those on the borders of such lands and angle and junction towers need to be more heavily built and bulky, although often lower in height.

Another important issue as far as sensitive design is concerned, relates to existing infrastructure such as roads and highways, railway lines, airports and pipelines. A transmission line must be designed to be compatible with these services. A case in point is the avoidance of the corrosion of old, unprotected pipes that results from electrolytic action caused by the proximity of an electric field.

Sensitive design can also assist in dealing with difficult terrain such as steep slopes, where a tower with two of the three sets of conductors suspended vertically on the down-slope side would result in a shorter tower. A horizontal configuration of sets of conductors would require a wider structure, resulting in a higher tower and more damage to the substrate. It is also important to design access roads, whether permanent or not, in an environmentally sound manner and other means of construction such as the use of helicopters and aerial stringing of conductors, should always be considered.

(e) Engineering constraints

At high altitudes where severe wind and snow occur, the reliability of high voltage overhead transmission lines is reduced and the cost of operation is increased. This is due to physical damage to the hardware imposed by increased wind and ice loads. It is a case of the environment inflicting constraints on the engineering component of a transmission line project. Areas prone to lightning strikes and bushfires can also impose constraints on the siting and operation of powerlines.

Resistance to extremely high winds, associated with episodic phenomena like tornadoes, cannot be absolutely provided for in the structural design of transmission line towers. The most cost-effective strategy is usually to provide for the sacrifice of one or two towers, but to limit a cascade of failures along a length of transmission line. The level of equipment reliability is balanced against reasonable cost. Notwithstanding the engineering feasibility, a transmission line route must be adjusted to existing and future network requirements, in terms of present and projected loads in the area being supplied.

Other engineering costs and constraints of transmission lines that impinge on the environment, are the level of atmospheric pollution of insulators, from salt-laden air near the coast, for instance, and the increased costs, in time and physical resources, that an isolated transmission line requires.

This section has provided a detailed inventory of all the known environmental impacts that result from the installation and operation of high voltage overhead transmission lines. However, before synthesising this into the comparative tables (section 3.5.) required for the analyses of case study EIRs in Chapter 4, two benchmark EIRs are examined.

3.4. EXAMINATION OF BENCHMARK EIRs

As described in the section on the method of study (section 2.4.), two EIRs from North America are used as benchmark documents. Since EIA is a relatively new discipline, much of the experience gained from the practice of EIA may not yet be incorporated in the literature. The purpose of using benchmark studies is to ensure that the identification of known environmental impacts resulting from high voltage overhead transmission lines, undertaken in the previous section, is comprehensive. It is also an opportunity to confirm that the EIA methods applied in these two power delivery projects are congruent with the findings in section 3.2. above, i.e. that linear EIA methods, including high voltage overhead transmission line development proposals, usually comprise either overlay mapping or tabulation methods, or both.

The two documents examined for this purpose are the EIRs for the 520 km Lennox - Hawthorne 500 kV transmission line project of Ontario Hydro in Canada in 1985, and the 130 km Clover - Carson 500 kV transmission line project of Virginia Power in the USA in 1992. These two projects were selected on the basis of recommendations from experienced EIA professionals, from both the applied and academic fields (Clara, pers. comm.; Hill, pers. comm.), as being representative of the state of the art in EIA. They also derive from a region of the world where EIA has a long history and is well established as a statutory requirement.

The examination of these two benchmark transmission line EIRs did elicit several environmental impacts that had not been identified in the literature reviewed earlier in this section, in sub-sections 3.3.1. to 3.3.3. However, none of these require a category in addition to those discussed above and are minor in the sense that they are specific to the detailed and appropriate levels already described. These environmental impacts are not listed separately here, since they are not easily distinguishable from those already identified and are subsumed in section 3.4. below.

As far as methods of EIA are concerned, the Lennox - Hawthorne 500 kV project in Canada employed a multi-step process, beginning with the mapping of nine land use and environmental factors and four socio-economic considerations, to produce constraint maps for the entire study area. From these, alternative corridors were identified and subsequently refined further by evaluation of specific alternative routes, selected by means of detailed and weighted tables of quantified information. The level of detail and comprehensiveness of this EIA is apparent in the fact that 6 000 landowners were consulted individually and 1 600 interested and affected parties attended public meetings.

A combination of both the linear EIA methods of overlay mapping and of tabulation was applied in this project. More significant, however, was that numerical manipulation was also applied, which resulted in quantification, weighting and aggregation typical of the Battelle EES (Bisset, 1980:34). Elements of Sondheim's matrix method (Sondheim, 1978), essentially a variation of quantification, weighting and aggregation (Bisset, 1980:34.), are discernible in this EIA.

The Clover - Carson 500 kV project in the USA was less complex, in terms of the level of detail and number of iterations in the EIA process, than the Canadian

example. No overlay mapping was employed but a network of possible routes, comprising 78 segments, was screened by a statistical manipulation of 19 weighted environmental variables. This numerical screening required impact weights to be determined for each variable, which were transferred to a common base to give Z-scores. A Z-score is the product of a statistical technique that measures the relative difference of one score from the average for the rest of the group of scores. These were then reduced to final impact scores, for each alternative route, in a comparative table. The numerical manipulation in this EIA also has elements in common with Sondheim's method.

A high level of sophistication is apparent in both the Lennox - Hawthorne and Clover - Carson transmission line EIAs, made possible by the application of computer-based information technology. The linear EIA methods employed for these projects are essentially forms of overlay mapping and of tabulation, with the quantitative elements being dealt with by means of sophisticated numerical manipulation based on quantification, weighting and aggregation typical of one of the five EIA methods identified in section 3.1. as being applicable to different kinds of projects, namely Sondheim's method (Sondheim, 1978).

In summary of the examination of benchmark transmission line EIRs, several less significant environmental impacts were identified and are incorporated in the comparative tables in section 3.5., and the EIA methods employed appear not to diverge from those that emerged from the review of linear EIA methods in particular, as reported in section 3.2.

The next section synthesises the known forms of environmental impacts that result from the installation and operation of high voltage overhead transmission lines, as identified in the preceding section. This provides tables for the

comparative evaluation of the case study EIAs, during the analyses of the case studies in Chapter 4 of this study.

3.5. TABULATION OF KNOWN TRANSMISSION LINE IMPACT DETERMINANTS

A synthesis of the known environmental impacts that result from high voltage overhead transmission lines is presented in the three synoptic tables that follow (Tables 5, 6 and 7). Each table lists one of the three groups of environmental impacts identified in the literature reviewed and discussed in detail in section 3.3. These are the biophysical, the socio-economic and the electrotechnical groups of impacts. The elements of these groups are presented as factors, since the individual impacts contained in the groups are stated as impact determinants in a generic sense, to allow for comparison.

Tables 5, 6 and 7 follow on the next three pages.

TABLE 5.

BIOPHYSICAL FACTORS	
Fauna	Collision/electrocution
	Rare/endangered species
	Nesting/roosting/movement
	Loss of electricity supply
	Benefit/decrement of changed habitat
Flora	Vegetation removal
	Conservation status
	Presence/threat of alien species
	Economic value
	Debris disposal
Physical factors	Wind damage
	Herbicide use
	Soil/bedrock exposure, erosion
	Terrain, soil stability/slope
	Wetlands/drainage lines
	Weather conditions
	Geotechnical aspect

Table 5. The biophysical factors that are evaluated in the EIA of high voltage overhead transmission line routing.

TABLE 6.

SOCIO-ECONOMIC FACTORS		
Land use		Existing land use (per land use type)
		Future land use (per planned change)
		Transportation systems
		Tenure/fabric
Visual		Homo/heterogenous landscape
		Line
		Form
		Colour
		Texture
Stakeholder		Absorption/insertion
	Consumer	Economic development
	Landowner	Property value
		Renunciation
	Community	Consumer behaviour
		Cultural resources/amenities
		Resettlement
		Labour
		Public services

Table 6. The socio-economic factors that are evaluated in the EIA of high voltage overhead transmission line routing.

TABLE 7.

ELECTROTECHNICAL FACTORS	
The servitude	Compensation
	Configuration of line/towers
	Dimension
Clearance distances	Horizontal/ vertical
	Security/public safety
Electrical effects	Electromagnetic fields
	Audible noise
	Radio interference
Design implications	Existing infrastructure
	Timing of activities
	Technical optimisation
Engineering constraints	Episodic events
	Pollution
	Access
	Costs

Table 7. The electrotechnical factors that are evaluated in the EIA of high voltage overhead transmission line routing.

These tables provide the basis for comparison in section 4.3. in the next chapter, where the six case studies are analysed in detail. The intention is to determine the effectiveness with which these known environmental impacts of high voltage overhead transmission lines are addressed, in keeping with Proposition Two as stated in section 2.5. A rating system is used and the results are presented graphically.

The sequential literature review described in Chapter 3 began with an examination of EIA methods at a general level (section 3.1.), to determine which methods are applicable to linear development proposals in particular. Overlay mapping and tabulation appear to be the methods of choice, although five other methods, namely cost-benefit analysis, the Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis, have not been discounted since they are regarded as being adaptable to different types of developments.

The examination of benchmark transmission line EIRs in section 3.4. included an appraisal of the methods applied and, besides overlay mapping and tabulation, numerical manipulation in the form of sequential refinements of quantifiable information in a Sondheim-type approach, is also discernible. With overlay mapping, tabulation and numerical manipulation in mind, section 4.2. investigates whether these are the most commonly used EIA methods for high voltage overhead transmission lines, and whether the other methods referred to as being adaptable to different types of developments, one of which is the Sondheim method, have particular relevance to transmission lines. Section 4.2. therefore addresses Proposition One, by examining whether the EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives are specific for the purpose.

The apparent paucity of EIA methods specified for linear development proposals in general, and for high voltage overhead transmission line route planning in

particular, necessitated the literature review moving from the level of sectoral EIA methods dealt with in section 3.2., to the project EIA level. It was at this stage that the environmental impacts that result from high voltage overhead transmission line projects in particular, were examined, described in detail and synthesised (sections 3.3. and 3.5.). The synthesis provided tables that form the comparative basis for the application of the research procedure that assesses how each impact is dealt with in the six EIRs that were used as case studies. Section 4.3. therefore addresses Proposition Two, by examining whether the environmental impacts of high voltage overhead transmission lines are effectively dealt with in the EIAs of power delivery projects in South Africa.

However, it is first necessary to motivate the selection of the case study EIRs.

4.1. SELECTION OF SOUTH AFRICAN CASE STUDY ENVIRONMENTAL IMPACT REPORTS (EIRs)

The case study EIRs used in this study were selected from the comprehensive library of such documents that is maintained by the Transmission Group of Eskom, South Africa's national electricity utility. Appendix I provides a list of the EIRs held in this library. It includes documents produced by, or on behalf of, Eskom's Transmission Group for high voltage overhead transmission line EIAs up to 1995.

The EIRs were initially subjected to a coarse screening. This screening was based on the criteria of comprehensiveness and technical detail that are required for

testing the propositions (section 2.5.). To be comprehensive, the EIRs had to reflect some detail in the evaluation of significant environmental impacts, and an indication of the mitigatory measures and the trade-offs between possible actions was sought. The technical detail contained in the EIRs was required to be provided in a structured and concise form, to ensure that the information being presented was accessible to the reader.

With these criteria of comprehensiveness and technical detail in mind, the recommendations from an experienced EIA practitioner (Clara, pers. com.) guided the initial screening. The following ten case study EIRs were selected as a result:

Kendal - Midas 400 kV, 1990
Muldersvlei - Stikland 400 kV, 1990
Hera - Westgate 275 kV, 1992
Hydra - Gamma 765 kV, 1992
Matimba - Insukamini 400 kV, 1992
Pegasus - Athene 400 kV, 1992
Everest - Merapi 275 kV, 1993
Ariadne - Hector 400 kV, 1994
Hector - Klaarwater 275 kV, 1995
Venus - Ariadne 400 kV, 1995

However, to provide for rigour in the selection of case studies, an objective means was sought to justify a final, smaller selection. The first criterion that the case studies were required to meet was that the examination of alternative routes had to form part of the EIA. Applying this test resulted in the Hera - Westgate 275 kV and the Matimba - Insukamini 400 kV EIRs, both dating from 1992, being immediately rejected, since neither provided for the evaluation of alternative routes in their EIAs. The Hera - Westgate 275 kV project did result

in a small portion of the total length of the transmission line being rerouted to accommodate future urban development, but this was to allow for single-purpose land use in a prescriptive manner. In the case of the Matimba - Insukamini 400 kV EIA, it was essentially a feasibility study of a predetermined route.

The remaining eight of the ten EIRs initially screened were then subjected to a further set of criteria in the final selection of case study EIRs. This set comprised five criteria, namely that the responsible practitioners, as well as the land use, topography, biome and climate occurring in the study areas, are suitably varied to ensure that the collective content of the EIRs are representative of high voltage overhead transmission line routing in South Africa. Table 8 on the next page provides the details which determined the selection of the final six case studies.

With reference to Table 8, the various practitioners responsible for the EIAs examined have been indicated by means of uppercase letters from A to E. Since practitioner A had undertaken four of the eight EIAs, it was necessary that the two EIRs being rejected would reduce this preponderance. Nevertheless, it was unavoidable that two of the final six EIRs were authored by practitioner A.

As far as land use is concerned, there is an equitable distribution in the EIRs finally selected between the rural category (extensive, low density settlement) and mixed category (more intensive activities and higher density settlement). It should be noted that high voltage overhead transmission lines serve a bulk electricity transportation purpose and are seldom planned to be routed within densely settled urban areas.

TABLE 8.

EIR	Practitioner	Land use	Topography	Biome	Climate
Kendal - Midas	A	Mixed	Undulating	Highveld, grassland	Temperate plateau
Muldersvlei - Stikland	B	Mixed	Flat	Coast, fynbos	Mediterranean
Hydra - Gamma	A	Rural	Flat	Karoo, scrub	Semi-arid plateau
Pegasus - Athene	C	Rural	Broken, undulating	Midlands, grassland	Plateau slopes, subtropical
Everest - Merapi	A	Rural	Flat	Highveld, grassland	Temperate plateau
Ariadne - Hector	D	Mixed	Undulating	Coast, grassland	Subtropical
Hector - Klaarwater	A	Mixed	Undulating	Coast, grassland	Subtropical
Ariadne - Venus	E	Rural	Undulating	Midlands, grassland	Plateau slopes, subtropical

Table 8. Case study selection criteria. The shaded EIRs are the six finally selected. The selection criteria and process are further described in the text.

Extreme terrain, in the form of steep mountains and deep valleys, is also generally avoided by high voltage overhead transmission line planners. Assuming that the more broken the topography, the more intensive are the environmental control measures required, the final selection of case studies tends away from EIAs on flat land, of which two were selected, towards EIAs in difficult terrain that make up the other four.

The biomes in Table 8 include a physiographic element according to Walton (1984:13). There are five biomes within which the EIAs were located, and each of these are represented by a case study EIR. An additional EIR from the "Midlands, grassland" biome was included, to ensure a more even distribution as far as topography and practitioner are concerned.

There are six climatic regions (Walton, 1984:19) within which the EIAs were located. Two of the transmission line routes pass from one region into another, both in the "Plateau slopes, subtropical" regions. A case study EIR was selected from each of the other four climatic regions that contain high voltage overhead transmission lines in their entirety, along with the two from the "Plateau slopes, subtropical" regions.

The Everest - Merapi 275 kV EIR was rejected to reduce the number of EIAs undertaken by practitioner A, who also undertook the Kendal - Midas 400 kV project in a similar biome and climate but with different topography. The Hector - Klaarwater 275 kV project was rejected to reduce the number of EIRs from areas of mixed land use, while also reducing the number undertaken by practitioner A. Similar topography, biome and climate is found in the Ariadne - Hector 400 kV project, undertaken by practitioner D. In this way, the widest variation of selection criteria is included in the final six case study EIRs selected.

Figure 2 is a map of South Africa that shows the geographical location of the final six case study high voltage overhead transmission lines

FIGURE 2.

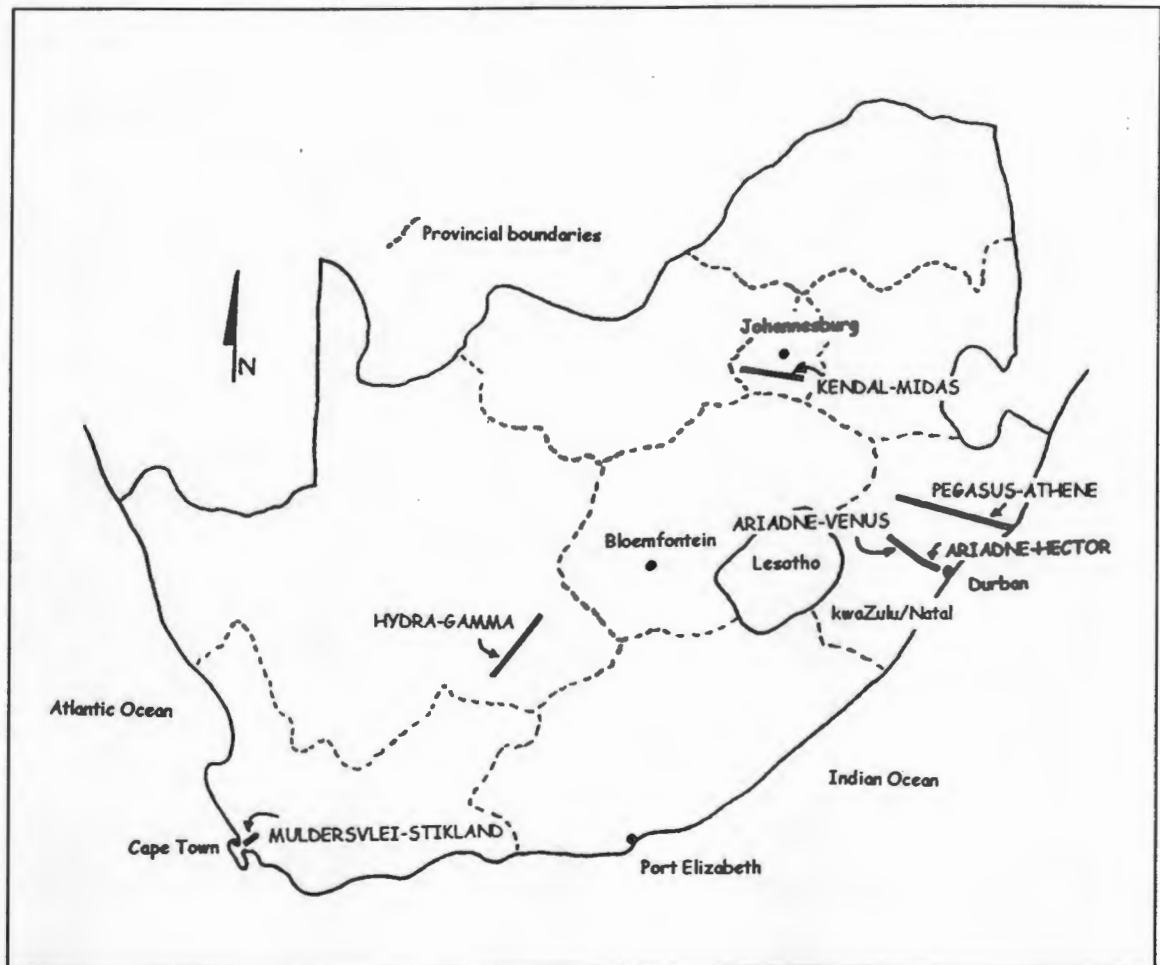


Figure 2. Map of South Africa showing the approximate geographical location of the six case study high voltage overhead transmission lines. Not to scale.

It will be seen that there is a preponderance of case studies from the kwaZulu/Natal province. This is due to the fact that the region has had the greatest need for increased electrical energy supply in the last several years.

The selection of the final six case study EIRs is believed to have been sufficiently objective in providing a body of information that is representative of the state of EIA practice for high voltage overhead transmission line projects in South Africa.

The final list of case study EIRs that are subjected to the research procedure in this chapter therefore comprise the following:

Kendal - Midas 400 kV	1990
Muldersvlei - Stikland 400 kV	1990
Hydra - Gamma 765 kV	1992
Pegasus - Athene 400 kV	1992
Ariadne - Hector 400 kV	1994
Ariadne - Venus 400 kV	1995

4.2. EXAMINATION OF CASE STUDY EIRs IN TERMS OF THE EIA METHODS APPLIED

The first proposition that this study sets out to test is whether the EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives in South Africa are specific for the purpose (section 2.5.). The detailed review of the literature on EIA methods generally, in section 3.1., and on linear EIA methods in particular, in section 3.2., showed that EIAs for linear development proposals usually comprise either overlay mapping methods or tabulation methods, or both.

Five other methods, namely cost-benefit analysis, the Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis, are regarded as being adaptable to different types of development and their relevance to high voltage overhead transmission line EIAs is also addressed in this section. The examination of benchmark transmission line EIRs from two highly developed countries in the Northern Hemisphere (section 3.4.), showed that numerical manipulation methods, in the form of sequential refinement of quantified information similar to the Sondheim method, were applied in the EIAs of these cases.

In this section, the six South African high voltage overhead transmission line EIRs are examined. This is to establish whether overlay mapping, tabulation or numerical manipulation methods of EIA were employed, or, in lieu of these, which other methods were employed. Each case study EIR is dealt with individually in the descriptions that follow. In support of the narrative contained in the text, Appendix II provides copies of relevant examples from the individual case study EIRs.

4.2.1. Kendal - Midas 400 kV, 1990:

The EIA methods employed in this case study comprised a detailed description of the "*environmental resources*" in the study area, grouped into physical, biological, socio-economic, sociocultural and aesthetic issues. (cf. Appendix II, page 131) The impacts of the proposed transmission line on these identified issues, and the impacts of the issues on the proposed transmission line, were then evaluated in terms of the specific impacts being high, moderate or low. It is unclear whether

this is in terms of magnitude or significance of impact. This evaluation is given in descriptive form in the text.

After evaluating the identified impacts, those that are regarded as moderate and high are further examined, in terms of the alternative routes within the preliminary corridors identified early in the study. Alternative routes, each comprising combinations of several sub-routes, are then described in terms of the trade-offs and mitigation that allowed for a particular route to be recommended. This evaluation and the recommendation that resulted, is provided in a descriptive text which contains quantified and qualified information, e.g. engineering costs and proximity to cultural resources respectively. (cf. Appendix II, page 132) While the information is not tabulated *per se*, it allows for comparative evaluation.

Detailed maps of the various environmental resources and issues are provided. However, overlay mapping is not undertaken.

The Kendal - Midas 400 kV transmission line EIA thus comprised descriptive text and non-overlay mapping methods, to deal with both quantified as well as qualified information.

4.2.2. Muldersvlei - Stikland 400 kV, 1990:

The study method applied in this EIR is described as comprising a "*plan phase*" and a "*route phase*". (cf. Appendix II, page 133) The plan phase consisted of a mapping exercise, where the environmental issues, represented in different colours, were recorded as separate overlays. Synthesis of these maps then resulted in the definition of corridors that "*contain the least environmental*

constraints for locating the power line". Thereafter, the route phase examined these corridors, both cartographically and by means of a sequential series of quantifications of 12 environmental factors, to ultimately select a *"preferred alternative route"*.

The environmental factors were ranked in order of importance and then weighted by a multi-disciplinary project team. Matrices were compiled and *"total impact scores"* were calculated. This was done by numerical manipulation of the ranked weights and quantified significance of each impact, *per* alternative corridor (cf. Appendix II, page 134) and subsequently *per* alternative route (cf. Appendix II, page 135). Quantification, weighting and aggregation typical of the Battelle EES and represented by a Sondheim-type approach - as applied in the two benchmark EIAs described in section 3.4. - were also applied in this EIA.

Separate matrices for the comparison of engineering costs of alternative corridors (cf. Appendix II, page 136) and alternative routes (cf. Appendix II, page 137) were also provided, although these did not include numerical manipulation.

Overlay mapping, tabulation, and numerical manipulation in the form of a sequential refinement of quantified information, comprised the methods applied in this case study.

4.2.3. Hydra - Gamma 765 kV, 1992:

This EIA was undertaken by the same practitioner as the Kendal - Midas 400 kV project and employed identical methods. The same sets of grouped *"environmental resources"* were evaluated in terms of the identified impacts

being high, moderate or low. (cf. Appendix II, page 138) It is unclear whether this is in terms of magnitude or significance of impact. This evaluation is reported in a descriptive text form and those impacts regarded as moderate and high are discussed in more detail in the selection, among alternatives, of the recommended route. Quantified information, e.g. line length, and qualified information, e.g. erosion-prone terrain, is provided. (cf. Appendix II, page 139) The various environmental resources and issues are depicted on detailed maps, but not in the form of overlays.

The Hydra - Gamma 765 kV transmission line EIA thus comprised descriptive text and non-overlay mapping methods, to deal with both quantitative as well as qualitative information.

4.2.4. Pegasus - Athene 400 kV, 1992:

The EIA methods applied in this case study began with a detailed description of *"criteria used in the selection and evaluation of a transmission line route"*. Although this description is comprehensive, it is generic and does not deal with the particular study area specifically. It does, however, provide a list of criteria against which the identified impacts were evaluated as being none, slight, moderate or severe. (cf. Appendix II, pages 140 and 141) It is unclear whether this is in terms of magnitude or significance of impact.

The corridor was divided into zones and a detailed table presented for the route alternatives within each zone. (cf. Appendix II, page 142) These tables could be termed matrices, given that information per route, per level of impact and per criterion, was evaluated. No numerical manipulation was undertaken, however, and

quantified information was presented as narrative. A descriptive text accompanies each table. (cf. Appendix II, page 143)

The selection of the route finally recommended is provided in descriptive text and the information in support of the recommendation is largely qualitative, e.g. *"little ecological impact"* and *"impact on urban settlement is slight"*. (cf. Appendix II, page 144) Quantified information is provided in the technical details of the proposed transmission line but was not reflected in the matrices.

Detailed maps of alternative routes are provided and a site analysis map combines several *"constraints"*, grouped as *"cultural, historic and prehistoric"*, and *"conservation"*. However, the site analysis map is made up of two parts and cannot be regarded as comprehensive overlay mapping.

The Pegasus - Athene 400 kV transmission line EIA thus comprised tabulated information, descriptive text and non-overlay mapping methods, that dealt with mainly qualitative information.

4.2.5. Ariadne - Hector 400 kV, 1994:

This case study begins with a narrative description of the environmental characteristics of the study area, grouped into biophysical aspects (cf. Appendix II, page 145), socio-economic issues, infrastructure, agriculture and socio-cultural issues. No evaluation *per se* is undertaken at this stage and only nominal statements (Harvey, 1969:309) such as *"railway lines in the study area pose no problems to the construction of a powerline"* (cf. Appendix II, page 146) and *"densely populated no-go areas will be avoided"*, are provided.

Following the description of the environmental characteristics, three issues are reported as being the most important, namely environmental quality, agriculture and human settlements. (cf. Appendix II, page 147) These are also described nominally and no structured evaluation is provided. However, a tabulated evaluation of another set of "*identified issues*" is presented, in which the specific issues are rated as having low, moderate or high potential impact. (cf. Appendix II, page 148) It is unclear whether this is in terms of magnitude or significance of the impacts. No route alternatives had been identified at this stage of the EIA.

A review of the information collected for the study was then undertaken, which was able to identify a variety of alternative routes. The review took the form of overlay mapping, although considerable descriptive detail was provided in the form of text. The product of the overlay mapping exercise was an "*environmental opportunities and constraints map*" which allowed a preferred route to be identified.

The EIA methods applied in the Ariadne - Hector 400 kV project thus comprised descriptive text, some tabulation and detailed overlay mapping. Besides easily quantifiable matters like line length, the information dealt with was largely qualitative.

4.2.6. Ariadne - Venus 400 kV, 1995:

This EIA begins with a detailed description of the "*biophysical, socio-economic and socio-cultural issues*" relevant to the study area, without evaluation being undertaken. Thereafter, the issues are logically grouped into "*categories of concern*" (cf. Appendix II, page 149) which are subjected to a particularly

comprehensive evaluation, according to "*assessment criteria*" that comprise a description of the nature and status of the criteria, an assessment of the extent, duration, intensity, probability, cumulative nature, certainty level, risk and reversibility of the impact, and a statement of the mitigative potential. (cf. Appendix II, page 150) This is a form of cross-tabulation suggested by Fuggle (1992:772-776) as being an EIA method suitable for use in South Africa. This method was not recorded in Table 2 as being specified for use with linear development proposals. Various qualitative and quantitative measurements are provided, in a descriptive text that includes several tables of summarised information. (cf. Appendix II, page 151) No corridor or route alternatives are in evidence at this stage in the EIA.

Based on the information already collected and evaluated, a variety of possible corridors were identified. These were evaluated numerically in matrices that dealt with classes of land use, agriculture, dry land crop potential and population densities. (cf. Appendix II, page 152) The matrices do not reflect manipulation in terms of weighting or sequential refinement and are essentially a form of tabulation. Each corridor is examined in detail, *per* the categories of concern and against the assessment criteria mentioned in the previous paragraph, i.e. according to the cross-tabulation method. A descriptive text is provided, which contains reference to quantified information. The text is interspersed with tables that reflect an evaluation of the particular category of concern in terms of the assessment criteria before and after mitigation. (cf. Appendix II, page 153) The information in these tables is qualitative.

Finally, significance rating tables are provided separately, which synthesise the impact categories for each of the corridor alternatives as being very high, high, medium or low, before and after mitigation. A considerable body of information in

text form is then presented in a concise summation of positive and negative impacts. (cf. Appendix II, page 154)

Maps of a variety of environmental aspects in the study area are provided, but no overlay mapping is undertaken.

Of note is that this case study EIR does not culminate in a recommendation for a particular route alternative. The decision-making is to take place as a separate stage. This is in keeping with the philosophy that EIA should inform decision-making, by providing additional information on the environmental implications of a proposed development.

The Ariadne - Venus 400 kV transmission line EIA thus comprised tabulation - which included a more sophisticated form of cross-tabulation similar to that suggested by Fuggle (1992:772-776) - and non-overlay mapping methods, of quantitative as well as qualitative information.

From the individual descriptions of each case study, relevant to the application of EIA methods for the routing of high voltage overhead transmission lines that comprise this section, section 5.1. in the next chapter provides a discussion of the findings and a summary in table form (Table 9).

4.3. EXAMINATION OF CASE STUDY EIRs IN TERMS OF THE EFFECTIVENESS WITH WHICH KNOWN ENVIRONMENTAL IMPACTS ARE ADDRESSED

To gain the necessary understanding of the effectiveness with which the known environmental impacts of high voltage overhead transmission lines are addressed, a matrix is compiled for each of the three groups of impacts. This is in keeping with the statement for discussion presented in Proposition Two in section 2.5. The three groups of impacts were described in detail in section 3.3 and synthesised in Tables 5, 6 and 7. They comprise the biophysical, socio-economic and electrotechnical groups of impacts and are stated as factors in the determination of specific impacts. A rating system is applied and the following symbols are used in the ratings:

- = impact not recognised
- + = impact recognised but not evaluated
- ++ = impact recognised and evaluated
- +++ = evaluation of impact resulted in mitigation

The awarding of a rating to an impact is achieved by careful scrutiny of the text of the particular case study EIR, in much the same way that the relevance of an EIA method to linear development proposals was determined in section 3.1.4. The contents of EIRs typically contain chapters dealing with, *inter alia*, the desirability of the project, technical requirements of the engineering hardware involved, a description of the study area, the identification of specific environmental impacts, evaluation of the identified impacts in the context of alternatives, and some form of recommendation.

By examining the details provided, firstly, in the descriptions of study areas and, secondly, in the identification of environmental impacts specific to particular projects, it is possible to determine which of the list of known impacts were recognised as relevant in that case. A simple statement of the existence of topographical features, for instance, in the description of a study area, is not an indication that these may result in environmental impact. However, when this description includes reference to possible impact, it is rated as having been recognised. In the identification of environmental impacts specific to a particular project, the impacts that are described have clearly been recognised. The symbol used in the matrices for impacts that are at least recognised in this way is □□+.

The next rating that is undertaken results from further examination of the relevant contents of the case study EIRs, to determine whether the impacts previously recognised are subject to some form of evaluation. As an element in EIA, evaluation refers to the process of obtaining, organising and weighing information on the consequences, or impacts, of alternatives. The way in which evaluation is done may vary from simple descriptive passages in the text, such as reference to an impact being high or low, or to the use of structured methods such as overlay mapping and tabulation. It is at this rating level that alternatives are addressed; for instance, different route options or different choices of tower design, i.e. trade-offs between alternatives. The symbol used in the matrices for impacts that are recognised and evaluated, *per* particular case study EIR, in the way described above is □++.

The final rating is then undertaken, by additional scrutiny of the text of the case study EIRs. The impacts that were recognised and evaluated are examined to determine whether specific remedial actions were stipulated, to mitigate adverse effects on the environment. It must be noted that a rating at this level does not imply that the impact has been dealt with in a way preferable to the previous

rating level. The intention is to gain as comprehensive a picture as possible of the extent of EIA within the entire transmission line project. The symbol used in the matrices for impacts that are recognised, evaluated and mitigated is +++ .

The matrices in which the effectiveness ratings are presented are contained in Tables 10, 11 and 12. These are provided as graphic representations in fold-outs on pages 108, 109 and 110, to enable direct reference to their content while examining the discussion of the findings in section 5.2. in the next chapter.

Appendix III provides the summary sheets which contain descriptions of the passages in the text of each case study EIR that formed the basis for the allocation of the qualitative ratings presented in Tables 10, 11 and 12.

In Chapter 5, where the findings of these analyses of the case studies are discussed, a qualitative opinion as to the effectiveness of EIA as it was applied to high voltage overhead transmission line route selection case studies in South Africa is given. This is the response to the question raised by Proposition Two as stated in section 2.5.

5.1. THE APPLICATION OF EIA METHODS IN HIGH VOLTAGE OVERHEAD TRANSMISSION LINE ROUTING

The sequential examination of the literature on EIA methods in general (section 3.1.), and on linear EIA methods in particular (section 3.2.), culminated in the conclusion that overlay mapping and tabulation methods were specifically recommended for linear development proposals. Five other EIA methods, namely cost-benefit analysis, the Fisher and Davies approach, Leopold's matrix, Sondheim's method and Sorensen's network analysis were identified as being adaptable to different types of developments.

The examination of two benchmark EIRs on high voltage overhead transmission line projects from developed countries in the Northern Hemisphere (section 3.4.), showed that, besides overlay mapping and tabulation EIA methods, numerical manipulation was also used, in the form of progressive refinement of quantified information, similar to the method proposed by Sondheim (1978).

Section 4.2. examined six South African case study transmission line EIRs, to determine which EIA methods had been applied in those projects. This section discusses the research findings from section 4.2., against the background of the information gleaned from the literature reviewed in Chapter 3, to shed light on the proposition that EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives are specific for the purpose.

Reference to "descriptive text" as an EIA method is in the context of it providing an indication of an evaluation which is reported in narrative form. Although not an EIA method *per se*, when used at the ordinal level of measurement, as in low, moderate or high, a simple description in the text can serve the purpose of evaluation. The ordinal level of measurement is where the activities that result in impacts are ranked in order of magnitude (Harvey, 1969:309). The reference to "non-overlay mapping" as an EIA method is also seen in the light of it being a means of conveying ordinal information, e.g. as a graphic representation of areas where a transmission line route is excluded, due to extreme topography, for instance.

The following sections discuss the EIA methods, as qualified in the preceding paragraph, identified as having been applied in the two benchmark EIRs and the six South African case study EIRs.

5.1.1. Descriptive text:

Descriptive text was used in the Kendal - Midas 400 kV case study EIA, the Hydra - Gamma 765 kV case study EIA, the Pegasus - Athene 400 kV case study EIA and the Ariadne - Hector 400 kV case study EIA.

Although this approach to the application of EIA is not easy to discern as a particular EIA method, it is able to convey both qualitative and quantitative information. A drawback is the difficulty, for the reader, of assimilating the information being conveyed in the EIR. Since any type of development that is subjected to EIA can be dealt with by means of descriptive text, it cannot be

regarded as an EIA method that is specific to the evaluation of high voltage overhead transmission line route alternatives.

5.1.2. Non-overlay mapping:

Non-overlay mapping was used in the Clover - Carson 500 kV benchmark EIA, the Kendal - Midas 400 kV case study EIA, the Hydra - Gamma 765 kV case study EIA, the Pegasus - Athene 400 kV case study EIA and the Ariadne - Venus 400 kV case study EIA.

As noted above, non-overlay mapping is essentially a means of conveying ordinal information in graphic form. While it can convey both qualitative and quantitative information, in a more accessible form than descriptive text, for instance, its use is not restricted to high voltage overhead transmission line route selection EIAs. It is thus not regarded as specific for the purpose.

5.1.3. Overlay mapping:

Overlay mapping was used in the Lennox - Hawthorne 500 kV benchmark EIA, the Muldersvlei - Stikland 400 kV case study EIA and the Ariadne - Hector 400 kV case study EIA.

This EIA method has a long history, beginning with the manual cartography of McHarg (1969) and applied more recently by means of computerised GIS technology (Sankoh *et al*, 1993). Although able to convey both qualitative as well as quantitative information, if only of a spatial nature, it has the drawback of only representing first-order impacts. Overlay mapping is generally regarded as

being particularly suitable for development proposals like transmission lines that have impacts characterised by wide spatial distribution (Julien, 1995:410). It is surprising, therefore, that only three of the total of eight EIRs examined, i.e. both the two benchmark and six South African transmission line case studies, used overlay mapping, particularly when seen against its prominence as an EIA method that is specified for linear development proposals.

To further investigate the infrequent use of overlay mapping as a specified linear EIA method, practitioners were asked how the selection of methods for high voltage overhead transmission line EIAs was undertaken and why overlay mapping was not more widely used. The development of EIA methods from less complicated methods such as descriptive text and non-overlay mapping, to the more complex tabulation and numerical methods, and to elaborate computer-based GIS applications, was indicated as a continuing process. A corridor selection application, generated from the "Regis" GIS platform, is due to become a standardised tool in Eskom's Transmission Group (Clara, pers. comm.). The complexity of a particular high voltage overhead transmission line project also dictates the selection of EIA methods, with transmission lines in heterogeneous landscapes containing many different environmental sensitivities requiring more elaborate EIA methods (van der Kooy, pers. comm.). The conclusion is that the low incidence of use of overlay mapping is not due to its unsuitability but to its recent availability in computer-based form, coupled with the limited resources available to capture the data needed to support a GIS application in a less-developed country such as South Africa.

5.1.4. Tabulation:

Tabulation was used in the Muldersvlei - Stikland 400 kV case study EIA, the Pegasus - Athene 400 kV case study EIA, the Ariadne - Hector 400 kV case study EIA and the Ariadne - Venus 400 kV case study EIA.

Tabulation EIA methods can vary, from simple comparative tables and sophisticated cross-tabulation matrices that convey ordinal information of a qualitative sort, to tables that convey quantitative information at the interval and ratio levels of measurement. Interval and ratio levels of measurement imply a rank-ordering of the units being measured, with the magnitudes between the units being known (Harvey, 1969:313). An example of comparative tabulation is to be found in the Pegasus - Athene 400 kV EIR (cf. Appendix II, page 142), a cross-tabulation example in the Ariadne - Venus 400 kV EIR (cf. Appendix II, page 150) and an example of quantitative tabulation in the Muldersvlei - Stikland 400 kV EIR (cf. Appendix II, page 136 and 137).

5.1.5. Numerical manipulation:

Numerical manipulation was used in the Lennox - Hawthorne 500 kV benchmark EIA, the Clover - Carson 500 kV benchmark EIA and the Muldersvlei - Stikland 400 kV case study EIA.

Although the results of this type of EIA method are often presented in a tabulated form, they are differentiated from the tabulation methods referred to in the previous section by the application of numerical manipulation to quantified information. Tabulation methods may present quantified information in terms of direct comparisons, e.g. transmission line lengths or number of

properties crossed by a proposed transmission line, but numerical manipulation requires additional value to be brought to bear by some form of arithmetic or statistical deployment. Typically, methods of quantification, weighting and aggregation as initiated by the Battelle EES (Bisset, 1980:34) are used. In the benchmark and case studies examined, these took the form of a Sondheim-type approach.

In summary of the discussion of EIA methods used in high voltage overhead transmission line route selection, this study has shown that overlay mapping, tabulation and numerical manipulation were applied in the benchmark and case study EIRs that were examined. However:

- Overlay mapping was not as widely used in practice as the literature would suggest. Only three of the eight EIRs examined applied this method. This is due not to it being unsuitable for the purpose but to its rapid development and recent availability in computer-based GIS form.
- Tabulation was applied in six of the eight EIRs that were examined, but in widely varying forms. Whether this is an indication that tabulation is not specifically suited for transmission lines is not clear, since its wide use for this purpose might indicate the converse.
- Numerical manipulation, in the form of a Sondheim-type method of quantification, weighting and aggregation, was discernible in the two benchmark EIRs and one South African case study.
- The other four EIA methods regarded as being adaptable to different types of developments, as identified in section 3.1, i.e. cost-benefit analysis, the

Fisher and Davies approach, Leopold's matrix and Sorensen's network analysis, did not emerge as being applied in the benchmark and case study EIAs for high voltage overhead transmission line route selection.

The table that follows on the next page (Table 9) provides a summary of the use of EIA methods in the combined total of eight EIRs of benchmarks and case studies.

This section has described considerable disparity in the use of EIA methods in the route selection of high voltage overhead transmission lines. Those methods identified as being applicable to linear developments in section 3.1., namely overlay mapping and tabulation, were indeed used. A form of tabulation not specified for linear use, namely Fuggle's (1992:772-776) cross-tabulation, was also applied. Of the five other EIA methods identified as being adaptable for different types of developments, only one was used. This was the Sondheim-type numerical manipulation.

The disparity in the use of EIA methods does not provide an unequivocal answer to the question about the methods specified for high voltage overhead transmission line route selection raised by Proposition One. However, an intuitive generalisation is possible - specified EIA methods are not always used, but in the application of these and other methods, an indication of continuing development of EIA methods is discernible. Conclusions to this generalised statement are provided in Chapter 6.

TABLE 9.

Method → EIR ↓	Descriptive text	Non-overlay mapping	Overlay mapping	Tabulation	Numerical manipulation
Lennox- Hawthorne	No	No	Yes	No	Yes
Clover- Carson	No	Yes	No	No	Yes
Kendal- Midas	Yes	Yes	No	No	No
Muldersvlei- Stikland	No	No	Yes	Yes	Yes
Hydra- Gamma	Yes	Yes	No	No	No
Pegasus- Athene	Yes	Yes	No	Yes	No
Ariadne- Hector	Yes	No	Yes	Yes	No
Ariadne- Venus	No	Yes	No	Yes	No
Total	4/8	5/8	3/8	4/8	3/8

Table 9. Summary of EIA methods used in EIRs examined.

5.2. THE EFFECTIVENESS WITH WHICH THE ENVIRONMENTAL IMPACTS OF HIGH VOLTAGE OVERHEAD TRANSMISSION LINES ARE ADDRESSED

The question of EIA methods dealt with in this study, as they apply to the evaluation of high voltage overhead transmission line routing alternatives, culminated in the discussion of Proposition One reported in the previous section. However, it was realised early in the literature review in Chapter 3 that a more detailed examination of the effectiveness with which the known impacts that result from high voltage overhead transmission line projects was required. This was necessary, in order to rigorously address the perceived problem of procedural compliance in EIA receiving more attention than ensuring the validity of its scientific content. Sections 3.3. and 3.5. respectively reviewed and synthesised the known transmission line impacts and section 4.3. applied the research procedure to the six South African case study EIRs. The result was the compilation of the effectiveness rating matrices presented in Tables 10, 11 and 12. This section discusses the findings of the effectiveness ratings, which are provided as fold-outs for direct reference on pages 108,109 and 110.

Before undertaking the analysis, it is necessary to gain a perspective on the four ratings that are used, to ensure that the analysis, based on the inductive reasoning approach described in section 2.5., is valid.

In cases where an impact was not recognised (□□□), or where an impact that was recognised was not evaluated (□□+), it is not possible to determine from examining the EIRs whether this was through oversight or whether the EIA practitioner applied an *a priori* judgement based on intuitive speculation (Harvey, 1969:35), about the relevance of the impact to the particular situation. Certain

forms of screening are generally applied in EIA, to determine the level at which an assessment is to be carried out. Section 2.3. dealt with screening in more detail. Examples in South Africa are the "listed activities" and "listed environments" in the IEM procedure (Department of Environment Affairs, 1997). These are activities or environments where an initial EIA is called for as a matter of course. By implication, activities or environments that are not listed, are not expected to result in, or receive, intensive impacts and are thus not required to be subjected to EIA. It is therefore legitimate that an EIA practitioner excludes certain impact determinants, without motivating the reason through comprehensive evaluation. Individual cases where an impact was not recognised, or where an impact that was recognised was not evaluated, are thus not seen as ineffectiveness in addressing the known impacts of high voltage overhead transmission lines. The scoping activity in EIA also can also result in certain environmental issues that are not identified as substantially significant being legitimately excluded from the assessment. Excluding certain impact determinants in this way, without providing the motivating reasons, was also not seen to be indicative of ineffectiveness in the practice of EIA in the case studies.

When viewed collectively, i.e. where all or most of the six case studies did not address an impact determinant, an intuitive generalisation is possible. This discussion of the effectiveness matrices in Tables 10, 11 and 12 is therefore based on the patterns that have emerged in the distribution of the rating symbols throughout a matrix and not on the rating contained in any individual cell within a matrix.

As far as the ratings are concerned that deal with impacts that are recognised and evaluated (□++), and impacts whose evaluation resulted in some form of mitigation (+++), it is clear that the evaluations influenced the decision-making

that guided the particular transmission line EIA. However, an impact evaluation that resulted in mitigation cannot be said to have been more effective than an impact whose recognition resulted in evaluation. An evaluation of an impact determinant known to be present in a given development proposal, could result in a neutral judgement as to its eventual impact. However, an evaluation would have taken place and the criterion of effectiveness would have been met. Therefore, impacts that are recognised and evaluated, and impacts whose evaluation resulted in some form of mitigation, are both regarded as having been effectively addressed. The numerical ratings given adjacent to each impact determinant in Tables 10, 11 and 12 represent the number of $\square++$ and $+++$ symbols in that particular row, as an indication of effectiveness.

Based on the collective perspective of ratings rather than individual contents of cells, and the grouping of impacts that are recognised and evaluated with those whose evaluation resulted in mitigation, the following sections discuss the effectiveness rating matrices for the biophysical, socio-economic and electrotechnical groups of impact factors. Impact determinants regarded as having been effectively addressed are indicated in bold type and the numerical effectiveness ratings that appear on Tables 10, 11 and 12 are given in parenthesis in the text that follows. Numerical ratings of $\geq 4/6$, i.e. 4/6, 5/6 and 6/6, indicate an impact determinant that is regarded as having been effectively addressed, while a rating of $\leq 3/6$, i.e. 3/6, 2/6, 1/6 and 0/6, indicate an impact determinant that was not effectively addressed.

5.2.1. Biophysical factors:

With reference to Table 10, the determinants of impacts related to fauna that received by far the most attention in the case studies, were the threats of

collision and electrocution (5/6), and undermining the conservation status of rare and endangered species' (6/6). Although the nesting, roosting and movement (2/6) of animals, and possible changes to animals' habitats (1/6), were also addressed, these were to a lesser extent, and the impact of the loss of electricity supply (0/6) to consumers due to animals damaging transmission lines and causing outages, was not considered at all.

As far as the determinants of impacts related to flora are concerned, the removal of vegetation (4/6) and the conservation status (6/6) of surrounding vegetation were effectively addressed, with the threat of alien vegetation (2/6) infestation receiving some attention. Impacts related to the economic value (1/6) of vegetation, the disposal of vegetation debris (0/6), damage to vegetation exposed to wind (1/6) and the use of herbicides (0/6) did not receive comprehensive attention.

The impact determinants that make up the physical group of factors, namely soil exposure and erosion (4/6), the slope and stability of soil (6/6), wetlands and drainage lines (6/6), weather conditions (5/6), and geotechnical conditions (4/6) were all effectively addressed.

In summary of the discussion of the biophysical group of factors, slightly more than half were effectively addressed in the case study EIAs. The emphasis among the faunal impact determinants (collision/electrocution; rare/endangered species) may be explained by public and authority concern and consequent media attention in the last few decades to certain birds, particularly raptors, being killed as a result of the presence of transmission lines, and the concerted effort on the part of electricity utilities to reduce these instances. However, it does not appear that the impact on the electricity utilities from the loss of supply due to collisions and electrocutions, has informed the decision-making in EIA. As regards

flora, the attention to the removal of vegetation, and its conservation status, indicates a general, over-arching concern. The more detailed issues received little attention and it is surprising that alien vegetation and herbicide use are not more thoroughly dealt with, since these are prominent issues among environmental managers. The effective attention to the physical group of factors is likely to be a mitigatory reaction to the common practice in South Africa in the past of gaining vehicle access to the entire length of transmission lines, regardless of the terrain. Avoidance of extreme terrain was also not always considered. The resulting substrate erosion and founding condition problems are legion (van der Kooy, pers. comm.).

5.2.2. Socio-economic factors:

Among the socio-economic factors (Table 11), the impact determinants related to land use are all effectively addressed, i.e. both existing (6/6) and future land use (5/6), transportation systems (5/6) and the tenure or fabric (4/6) of the landscape.

As far as visual impact determinants are concerned, the issues of homogenous and heterogenous landscape (4/6) characteristics, the visual appearance of lines (4/6) in the landscape and the absorption or insertion (6/6) of transmission line structures into the landscape, were effectively addressed. The form (1/6), colour (3/6) and texture (1/6) of transmission lines were not considered in detail.

The impact determinants related to stakeholder factors that received the most attention were the landowner issues of diminished property values (5/6) and renunciation (5/6) resulting from expropriation or restriction on usage, and the community concerns related to cultural resources (6/6). Economic development

opportunities on the part of consumers (1/6), and, on the part of the community, changed consumer behaviour (0/6), resettlement (3/6) threats, the influence of transmission line construction and operation activities on labour (2/6) markets, and the capacity of social services (0/6) to deal with episodic events related to transmission lines, are not effectively addressed.

In summary of the discussion of the socio-economic group of factors, more than half were effectively addressed in the case study EIAs. The land use impact determinants were all effectively addressed, possibly as a result of these being more prominent in linear developments generally. This could be explained by the numerous different land use zones that are affected, as compared to site-specific developments which usually occur in a single land use zone. As far as the visual factors are concerned, land use zones are manifested as landscapes. The variety of landscapes affected by linear developments may also explain the emphasis on homogeneity and heterogeneity in the landscape, as well as the attention to ensuring that a transmission line is absorbed into a landscape to reduce the visual obtrusiveness, or inserted into a landscape already containing linear features. Line as a visual impact determinant is understandably well attended to, given the physical appearance of transmission lines. Among the stakeholder factors, those impact determinants that are effectively addressed relate to property issues and to cultural resources, which illustrate a strong land surveying influence, and the emergence of social concerns in EIA, respectively. However, besides cultural resources, the other stakeholder impacts related to consumers and communities are not well addressed.

5.2.3. Electrotechnical factors:

The ratings for the electrotechnical factors presented in Table 12 show that, as far as the servitude is concerned, the only impact determinant effectively addressed was that of compensation (4/6) to the owner of the land affected by a transmission line. The configuration (1/6) of the conductors that comprise a transmission line, and the dimensions (2/6) in terms of the required width of a servitude, were not generally considered.

The impact determinants related to clearances, i.e. the horizontal and vertical clearance (2/6) distances, the clearance distances at mid-span and at towers (0/6) in terms of conductors swinging, and the clearance distances require to ensure security and the safety of the public (2/6), were not effectively addressed.

The impact determinants related to electrical effects, i.e. the perceived health threats from electromagnetic fields (2/6), the audible noise (0/6) from the corona effect, and the interference with radio telecommunications (2/6), were not effectively addressed.

The impact determinants related to the design implications of transmission lines that were effectively addressed were existing infrastructure (5/6) and technical optimisation (5/6). Both of these provide opportunities for optimisation, e.g. using hardware more efficiently, although they can also be constraints, e.g. restricting the permissible angles at bends in a line. The timing of activities (3/6) was not effectively addressed.

Engineering constraints that were effectively addressed were the impact determinants of episodic events (5/6) like fires, difficulties of vehicle access

(5/6) to transmission lines, and cost (6/6) impacts resulting from isolated transmission lines or inaccessible terrain. The potential impact from the pollution (2/6) of insulators and conductors, for instance from dust deposits in arid areas prone to wind storms, was not effectively addressed.

In summary of the discussion of the electrotechnical group of factors, slightly more than a third were effectively addressed in the case study EIAs. In numeric terms, therefore, the impact determinants that make up the electrotechnical factors were the least effectively addressed of the three groups examined. As far as the servitude is concerned, compensation was the only impact that was comprehensively dealt with and the unavoidable property ownership issues of title deed conditions and monetary costs could explain this. Clearances and electrical effects were not effectively addressed. The design implication determinants related to existing infrastructure and technical optimisation were effectively dealt with and a willingness to apply innovative design was apparent. Designing appropriate time schedules, into construction activities, for instance, received less attention. The impact determinants related to engineering constraints that were effectively addressed, i.e. episodic events, access and costs, were dealt with in terms of their rigid technical characteristics. The way in which the influence of these impacts was able to inform the decision-making, shows integration of engineering concerns into the EIAs.

As indicated at the end of the analyses of the case studies in section 4.3., the effectiveness rating matrices (Tables 10, 11 and 12) are provided as fold-outs, to enable direct reference to their content while examining the discussion of the findings in this section. These fold-outs follow on pages 108, 109 and 110.

The letters A to F on the horizontal axis of the matrices indicate the particular EIR case study, as follows:

A = Kendal - Midas 400 kV, 1990

B = Muldersvlei - Stikland 400 kV, 1990

C = Hydra - Gamma 765 kV, 1992

D = Pegasus - Athene 400 kV, 1992

E = Ariadne - Hector 400 kV, 1994

F = Ariadne - Venus 400 kV, 1995

Tables 10, 11 and 12 follow on the next three pages.

TABLE 10.

BIOPHYSICAL FACTORS

FAUNA	A	B	C	D	E	F
Collision/electrocution 5/6	□□□	+++	□++	+++	□++	+++
Rare/endangered species 6/6	+++	□++	□++	+++	□++	+++
Nesting/roosting/movement 2/6	□□□	□□□	□++	□□+	□□□	+++
Electricity supply loss 0/6	□□□	□□□	□□□	□□□	□□□	□□□
Changed habitat 1/6	□□□	□□□	□□□	□□+	□□□	+++
FLORA	A	B	C	D	E	F
Vegetation removal 4/6	+++	+++	□□+	+++	□□+	+++
Conservation status 6/6	+++	+++	□++	+++	+++	+++
Alien vegetation threat 2/6	□□□	+++	□□□	□□□	□□□	□++
Economic value 1/6	□□□	□□□	□□□	□□□	□++	□□□
Debris disposal 0/6	□□□	□□□	□□□	□□+	□□□	□□□
Wind damage 1/6	□□□	□□+	□++	□□□	□□□	□□□
Herbicide use 0/6	□□□	□□□	□□□	□□□	□□□	□□□
PHYSICAL FACTORS	A	B	C	D	E	F
Soil exposure/erosion 4/6	□++	□□□	+++	+++	□□+	+++
Soil stability/slope 6/6	+++	□++	+++	+++	□++	+++
Wetlands/drainage lines 6/6	□++	□++	□++	+++	□++	□++
Weather conditions 5/6	□++	□++	□++	□□□	□++	□++
Geotechnical 4/6	□++	□++	□++	□□□	□++	□□□

Table 10. Effectiveness rating matrix for biophysical impact factors in six South African case studies (A-F). Numerals reflect effectiveness rating for each impact determinant. (□□□ = impact not recognised; □□+ = impact recognised but not evaluated; □++ = impact recognised and evaluated; +++ = evaluation of impact resulted in mitigation.)

TABLE 11.

SOCIO-ECONOMIC FACTORS

LAND USE	A	B	C	D	E	F
Existing land use, per type 6/6	+++	+++	□++	+++	+++	+++
Future land use, per type 5/6	+++	+++	□++	□□+	+++	□++
Transportation systems 5/6	□++	□++	□++	□□+	□++	+++
Tenure/fabric 4/6	□++	□□□	□++	□□+	□++	+++
VISUAL	A	B	C	D	E	F
Homogenous landscape 4/6	□□□	+++	+++	□□□	+++	□++
Line 4/6	□□□	□□□	+++	+++	+++	+++
Form 1/6	□□□	□++	□□+	□□□	□□□	□□□
Colour 3/6	□□□	□□□	□++	□++	□□□	□++
Texture 1/6	□□□	□□□	□++	□□□	□□□	□□□
Absorption/insertion 6/6	+++	□++	+++	+++	+++	+++
STAKEHOLDER	A	B	C	D	E	F
Consumer: economic devel. 1/6	□□□	□□□	□□□	□□□	□□+	□++
Landowner: property value 5/6	□++	□++	+++	□□□	+++	□++
renunciation 5/6	+++	+++	□□□	□++	+++	+++
Community: consumerism 0/6	□□□	□□□	□□□	□□□	□□□	□□□
cultural resources 6/6	+++	+++	□++	+++	□++	+++
resettlement 3/6	□□□	□++	□□□	+++	□□+	+++
labour 2/6	□□□	□□□	□□□	□++	□□□	□++
services 0/6	□□□	□□□	□□□	□□□	□□□	□□□

Table 11. Effectiveness rating matrix for socio-economic impact factors in six South African case studies (A-F). Numerals reflect effectiveness rating for each impact determinant. (□□□ = impact not recognised; □□+ = impact recognised but not evaluated; □++ = impact recognised and evaluated; +++ = evaluation of impact resulted in mitigation.)

TABLE 12.

ELECTROTECHNICAL FACTORS

SERVITUDE	A	B	C	D	E	F
Compensation 4/6	+++	□++	□□□	□□□	□++	□++
Line configuration 1/6	□++	□□□	□□□	□□□	□□□	□□□
Dimension 2/6	□□□	□++	□□□	□□□	□++	□□□
CLEARANCES	A	B	C	D	E	F
Horizontal/vertical 2/6	□□□	□□□	□□□	□□□	□++	□++
Mid-span/tower 0/6	□□□	□□+	□□□	□□□	□□□	□□□
Security/public safety 2/6	□□□	+++	□□□	□□□	□□+	+++
ELECTRICAL EFFECTS	A	B	C	D	E	F
Electromagnetic fields 2/6	□□□	□□+	□□□	□□+	□++	+++
Audible noise 0/6	□□□	□□+	□□□	□□□	□□□	□□□
Radio interference 2/6	□□□	+++	□□□	□□□	□□□	+++
DESIGN IMPLICATIONS	A	B	C	D	E	F
Existing infrastructure 5/6	+++	+++	+++	□□+	□++	+++
Timing of activities 3/6	+++	+++	□□□	□□□	□□□	□++
Technical optimisation 5/6	□++	+++	□□□	+++	□++	+++
ENGINEERING CONSTRAINTS	A	B	C	D	E	F
Episodic events 5/6	□□□	□++	□++	+++	+++	+++
Pollution 2/6	□□□	□□□	□□□	□□□	+++	□++
Access 5/6	□++	□□□	□++	+++	□++	+++
Costs 6/6	+++	□++	+++	+++	+++	□++

Table 12. Effectiveness rating matrix for electrotechnical impact factors in six South African case studies (A-F). Numerals reflect effectiveness rating for each impact determinant. (□□□ = impact not recognised; □□+ = impact recognised but

not evaluated; □++ = impact recognised and evaluated; +++ = evaluation of impact resulted in mitigation.)

In summary of this section (5.2.) as a whole, the biophysical and socio-economic groups of factors are more effectively addressed than the electrotechnical ones. It appears that the focus of attention is at a generic level, where the impacts are most prominently manifested, and that the more detailed issues receive less attention. Examples of this selectivity in emphasis are the attention to birds colliding with, or being electrocuted by, transmission lines, but little attention to the resultant unreliability of electricity supply, the removal of flora receiving attention but not the threat of encroachment by alien species, and that cultural resources were the only issue to be addressed among the socio-economic factors related to the community. The comprehensive treatment of physical impacts may be explained by the fact that erecting a transmission line requires massive pieces of structural hardware for the towers and lengths of cable for the conductors to be introduced into the environment, with concomitant physical damage. Once erected, transmission lines have little impact on the physical environment (Thorsell, 1976:6). The impact determinants that are effectively addressed among the electrotechnical group of factors show an association with an exacting engineering approach, but this is explained by the origins of EIA in the largest electricity utility in South Africa, Eskom, being known to have derived from the engineering disciplines, specifically land survey. The lack of attention to the effects of electromagnetic fields is surprising, given the extent of the perception that these are harmful to the health of humans and other life forms.

The thorough discussion in this section was possible because of the detailed information contained in the case study EIRs that were examined. This extensiveness of detail provided in the EIRs is in itself an indication of effectiveness. However, the socio-economic factors, closely followed by the

biophysical factors, were the most effectively addressed, with slightly more than half of the impact determinants in each case receiving the required attention. Among the electrotechnical factors, just more than a third of the impact determinants were effectively addressed. In response to the question posed by Proposition Two, indications are thus that the environmental impacts of high voltage overhead transmission lines are reasonably effectively addressed in the EIAs of power delivery projects in South Africa. However, this statement is more valid for some of the groups of factors than others, and there are differences in emphasis among the impact determinants addressed in the case studies. Conclusions to this statement, and the statement that closed section 5.1, are provided in Chapter 6.

There are two further observations that are worth noting. Firstly, five of the six South African case studies culminated in the identification and recommendation of a preferred route alternative. It appears that in these cases the EIA practitioners themselves were responsible for the recommendation of the final transmission line route. This is not consistent with the view, held by some EIA practitioners (e.g. Lee, 1983), that EIA should only provide additional information about the environmental consequences of particular developments, to inform the decision-makers. Secondly, it appears that avoidance by means of manipulating route alignment was the most common form of mitigation of the environmental impacts that result from high voltage overhead transmission line projects.

This chapter has provided a discussion of the findings of the application of the research procedure, in addressing the propositions presented in section 2.5. The next chapter draws conclusions and provides recommendations.

The propositions stated in section 2.5. were discussed in the previous chapter. Proposition One, that the EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives are specific for the purpose, cannot be unequivocally proven (section 5.1.). Proposition Two, that the environmental impacts of high voltage overhead transmission lines are effectively addressed in the EIAs of power delivery projects in South Africa, appears to be generally valid (section 5.2.). The conclusions drawn from the testing of the propositions, and appropriate recommendations based on insights gained by this study, are presented in this chapter.

6.1. THE THEORY OF EIA METHODS IN THE ROUTING OF HIGH VOLTAGE OVERHEAD TRANSMISSION LINES

As far as the application of EIA methods to transmission line projects is concerned, the conclusion that Proposition One cannot be unequivocally proven is derived from the disparity of methods described in the two benchmark and six case study EIRs. Specified linear EIA methods are used in about half of the transmission line cases examined, but the development of these and other methods continues. Although the literature review that established the theoretical basis for the study showed that forms of overlay mapping and

tabulation are the EIA methods of choice for linear development proposals, in the practice of high voltage overhead transmission line route selection these methods were not used exclusively or extensively. It was particularly surprising that overlay mapping was used in only three of the total of eight EIRs examined. Tabulation was slightly more extensively used, i.e. in four of the eight EIRs examined, but in widely varying forms. The most sophisticated tabulation that was applied was a form of Fuggle's (1992:772-776) cross-tabulation method, undertaken in one of the South African EIAs.

The literature review also showed that several other EIA methods were regarded as being adaptable to different types of developments. A form of numerical manipulation that uses quantification, weighting and aggregation with similarities to one of these other methods (Sondheim, 1978), was used in the two benchmark EIAs but only in one South African case study.

Having concluded that the EIA methods applied in the evaluation of high voltage overhead transmission line routing alternatives cannot generally be said to be specific for the purpose, the question of whether this is a shortcoming or not, must be addressed. Viewed in isolation, the conclusion may well appear to indicate a shortcoming. However, the second proposition tested in this study showed that the known environmental impacts that result from high voltage overhead transmission line projects are reasonably effectively addressed in the South African case studies. Therefore, the lack of clarity on EIA methods specified in the practice of transmission line route selection appears not to detract from the rigour with which these projects were undertaken. The variety of EIA methods applied to the transmission line projects that were examined did not inhibit the attention in each assessment to either their procedural or technical content. The

inability to prove Proposition One valid is thus not an indictment of the practice of EIA for high voltage overhead transmission line route selection in South Africa..

To offer recommendations about the application of EIA methods in transmission line route selection would, therefore, be inappropriate. Thompson's (1990:248) opinion that properly understanding the characteristics of a particular development proposal - and how these interact with the environment - is more important than the use of standardised EIA methods, appears to be manifested in practice. Brown and Hill (1995) also call for acknowledging a wider range of objectives in the practice of EIA and the conclusion of this part of the study reflects an approbative flexibility and dynamism in the application of EIA methods in high voltage overhead transmission line route selection in South Africa.

6.2. THE PRACTICE OF EIA IN THE EFFECTIVENESS OF HIGH VOLTAGE OVERHEAD TRANSMISSION LINE ROUTE SELECTION

The conclusion that Proposition Two is generally valid was based on the discussion in section 5.2. of the detail contained in the effectiveness rating matrices presented in Tables 10, 11 and 12.

The biophysical and socio-economic groups of factors were more effectively addressed in proportional terms than the electrotechnical group. Within the

latter, a beneficial integration of engineering innovation into project decision-making was discernible, in the willingness to employ designs that could ameliorate environmental impacts. The attention to the more conspicuous impacts at a general level reported in section 5.2., indicates that the effectiveness with which the known environmental impacts of high voltage overhead transmission lines are addressed can be further improved. No doubt the practice of EIA for transmission line route selection is evolving and will continue to do so.

The two broad impressions from the effectiveness rating analysis are that the most prominent environmental issues receive the most attention and that EIA in the transmission of bulk electricity in South Africa reflects its engineering and land survey origins. Neither of these are negative features of the practice of EIA. However, the following paragraph provides recommendations that could accelerate the improvement in the effectiveness of high voltage overhead transmission line route selection.

The secondary effects among the biological impact determinants should be more effectively addressed, e.g. electricity supply loss from wildlife interactions with transmission lines, alien vegetation encroachment and herbicide use. Among the socio-economic group of factors, more attention to stakeholder impacts that relate to the affected community, such as changes in consumer behaviour and employment opportunities, is required. The perceived negative effects on health of electromagnetic fields, among the electrotechnical group of factors, should be addressed as a precautionary measure.

In summary of the conclusion to this study, it appears that the perceived problem in transmission line EIA in South Africa of over-emphasis on procedural compliance and neglect of the validity of its technical content, is unfounded. The examination of the EIRs of high voltage overhead transmission line EIAs in particular showed reasonably effective attention to the environmental impacts known to result from this type of linear development. Verifying the assumption that certain EIA methods specified for the purpose are applied as a matter of course, proved illusive but was not regarded as a shortcoming.

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APPENDIX I

LIST OF ENVIRONMENTAL IMPACT REPORTS (EIRs) HELD IN THE LIBRARY OF ESKOM'S TRANSMISSION GROUP, ENVIRONMENTAL SECTION, IN 1995.

• Bacchus - Proteus 400 kV	undated
• Kleinmond - Hanglip 66 kV	undated
• Matimba - Pluto/Midas 400 kV (Part II)	1985
• Crocodile - Dalkeith 88 kV	1990
• Kendal - Midas 400 kV	1990
• Muldersvlei - Stikland 400 kV	1990
• Poseidon - Grassridge 400 kV	1990
• Poseidon - Neptune 400 kV	1990
• Camden - Duvha 400 kV	1991
• Egmont - Beaver lines	1991
• Gamma - Omega 765 kV	1991
• Tugela - Sorata 275 kV	1991
• Hera - Westgate 275 kV	1992
• Hydra - Gamma 765 kV	1992
• Majuba - Pegasus 400 kV	1992
• Matimba - Insukamini 400 kV	1992
• Pegasus - Athene 400 kV	1992
• Everest - Merapi 275 kV	1993
• Ariadne - Hector 400 kV	1994
• Hector - Klaarwater 275 kV	1994
• Matimba - Bulawayo 400 kV	1994
• Ariadne - Venus 400 kV	1995
• Prairie - Zombodzi 275 kV (Vol 2)	1995

EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN
SECTION 4.1. Case study EIR: Kendal - Midas 400 kV, 1990.

4. ENVIRONMENTAL RESOURCES IN THE STUDY AREA

The investigation of the study area identified all physical, biological, socio-economic, socio-cultural and aesthetic issues, assessed the impact of the project on them and vice-versa.

4.1 PHYSICAL ISSUES

4.1.1 Land Form

The area is in general a undulating landscape averaging an altitude of 1 550 metres, broken in the east by the Suikerbosrand (Fig.4.1.1.1) (1 800m) and in the west by the Gatsrant (1 700m) (Fig. 4.1.1.2), both ridges running in a east-west direction.

The impact of these features is low, due to their location and direction, allowing the use of low lands (Map 3).

Source of information - 1:10 000 orthophotos, 1:50 000 maps, vehicle and helicopter site visits.

4.1.2 Water Resources

The water courses in this area, are tributaries of the Vaal River, of which the Klipriver is the most significant, passing near Daleside, towards Vereeniging (Fig. 4.1.2)

Into this river, from the east, runs the Rietspruit, north-west of Suikerbosrand.

West of Evaton the Leeuspruit follows a south- easterly direction, towards Vanderbijlpark.

Their impact is low due to their size, presenting no physical barrier to the line or being impacted by it.

Same sources of information as above.

4.1.3 Geology

The region is underlain by sedimentary Karoo Rock formation, built up by sandstone and shale. This has disintegrated, exposing the more resistant pre-Karoo formations of the Witwatersrand ridges and the Suikerbosrand, Ventersdorp lava formation. (Maps 5 and 12 and geological report-Appendix - 2.)

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Kendal - Midas 400 kV, 1990.

5. DISCUSSION

In the discussion of the alternative line routes, only the moderate to high impact issues will be referred to.

5.1 POSSIBLE CORRIDORS AND ALTERNATIVES

In view of the degree of urban development of the study area, the identification of preliminary corridors was limited to a single one, with variable widths (map 3). This was particularly due to concentration of existing zones and the reservation of vast tracts of proposed areas for urbanization of low income population (map 9). The result was a restriction on the identification of the alternative routes (\pm 100 metres wide) only within this corridor, becoming more of variations of a single route ("red").

These variations are located in three areas: the first north-west of Suikerbosrand (A,B,C) (shooting range, power lines and ancient villages) the second West of Vereeniging highway (D,E,F) (Daleside golf club, Blue Saddle Ranch Township and Walkerville Fruit Farms) and the third north-west of Evaton (G,H,I) - proposed Orange farm and Rietfontein development areas.

5.1.1-ALTERNATIVES A/B/C - (SUIKERBOSRAND AREA) (MAP 4)

- "B" is the cheapest (R5,2million, - Appendix 8), but passes close to the farm house (150m) and over one ancient villages (fig 4.4.2).

- "C" is the most expensive (R6,7 million) and as per 4.3.12 runs along the Suikerbosrand Nature Reserve and on side sloped ground.(map4)

- "A" costs R5,9 million and passes further away from the farm house, hidden behind a koppie (fig 5.1.1.and 4.3.1.2) and then parallel for 2,5km to a Rand Water Board pipeline servitude (fig 4.3.1).

- Although alternative "A" is more expensive than "B", it has less impact, by avoiding the farm house, the ancient village and running parallel to an existing servitude.

5.1.2 ALTERNATIVES TO D/E/F (DALESIDE) (MAP 4)

- Alternative "D" (5,2 million - Appendix 8) runs along the northern slopes of the hills (Fig 4.2.1.1) south of the road K158 from Walkerville to Daleside, which crosses an unspoiled valley. After crossing a "neck" in the hills, (fig 5.1.2) south of the Blue Saddle Ranch Township, it would be in full view from the road for 3,4 km North of the road (although with a good background for 1,5 km) and 1,5 km south of it, with about 1,6 km along the horizon on both sides. It would interfere with 0,7 km of natural vegetation, would also be affected by a side slope and passes 200 m from the farm house (fig 4.2.1.1)

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

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4. STUDY METHOD

The environmental impact assessment process used in this study comprised two phases : a plan phase in which corridors were selected, and a route phase.

(i) PLAN PHASE

Aerial photographs (1988) and topographical maps both at a scale of 1:50 000 were analysed in conjunction with relevant environmental data collected for the project study area. All environmental issues were then mapped separately as colour overlays. These were analysed in relation to a base locality map with the objective of defining corridors within the overall project study area that contain the least environmental constraints for locating the power line. Three corridors of approximately 100m in width were thus selected.

(ii) ROUTE PHASE

Orthophotographs (1983) at a scale of 1:10 000 were updated using the aerial photographs, and were then studied together with 1:10 000 Cadastral plans, and 1:5 000 and 1:2 000 noting sheets. Four alternative routes were obtained by a detailed investigation and evaluation of the environmental, technical and economic constraints within a favoured central and northern corridor. After three intensive site visits (one on the ground, and two with the aid of a helicopter) as well as two public meetings, a preferred alternative route was selected as the best compromise between environmental, technical and economic considerations.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

**MULDERSVLEI-STIKLAND
400kV TRANSMISSION LINE**

ENVIRONMENTAL MATRIX

ENVIRONMENTAL FACTOR	WEIGHT	ALTERNATIVE CORRIDORS		
		NORTH	SOUTH	CENTRAL
Farming	5,0	2 10	3 15	2 10
Mining	3,3	2 6,6	1 3,3	0 0
Residential Development Potential	2,5	3 7,5	2 5,0	2 5,0
Heritage	2,0	0 0	3 6	1,5 3,0
Aesthetics	2,0	1 2	3 6	2 4
Size of Property	1,7	3 5,1	1 1,7	2 3,4
Homesteads	1,4	3 4,2	2 2,8	2,5 3,5
Endangered Habitats	1,4	1 1,4	0 0	1 1,4
Soil Fertility	1,4	1 1,4	3 4,2	2 2,8
Recreation	1,0	0 0	1 1	0 0
Topography	1,0	1 1	3 3	1 1
Soil Type	0,9	3 2,7	1 0,9	3 2,7
TOTAL IMPACT SCORE		41,9	48,9	36,8

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

**MULDERSVLEI-STIKLAND
400kV TRANSMISSION LINE**

ENVIRONMENTAL MATRIX

ENVIRONMENTAL FACTORS	ALLOCATED WEIGHT	ALTERNATIVE ROUTES			
		NORTH (A)	PARALLEL NORTH (B)	PARALLEL SOUTH (C)	DISMANTLE (D)
Farming	5,0	2 10	1,5 7,5	2 10	1,5 7,5
Mining	3,3	1 3,3	1 3,3	0 0	1 3,3
Residential Development Potential	2,5	2 5,0	2 5,0	2 5,0	2 5,0
Heritage	2,0	1 2,0	1,5 3,0	1,5 3,0	1,5 3,0
Aesthetics	2,0	3 6,0	2 4,0	2 4,0	1,5 3,0
Size of Property	1,7	3 5,1	2 3,4	2 3,4	2 3,4
Homesteads	1,4	1,5 2,1	1 1,4	2,5 3,5	1 1,4
Endangered Habitats	1,4	1 1,4	1 1,4	1 1,4	1 1,4
Soil Fertility	1,4	2 2,8	2 2,8	2 2,8	2 2,8
Recreation	1,0	1 1,0	0 0	0 0	0 0
Topography	1,0	1 1,0	1 1,0	1 1,0	1 1,0
Soil Type	0,9	3 2,7	3 2,7	3 2,7	3 2,7
TOTAL IMPACT SCORE		42,4	35,5	36,8	34,5

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

**MULDERSVLEI-STIKLAND
400kV TRANSMISSION LINE**

ENVIRONMENTAL/COST MATRIX

FACTOR	ALTERNATIVE CORRIDORS		
	NORTH	SOUTH	CENTRAL
Environmental / Technical	41,9	48,9	36,8
Length (km)	15,47	17,45	16,71
Construction Costs	R 9 204 650,00	R10 382 750,00	R 9 942 450,00

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

**MULDERSVLEI-STIKLAND
400kV TRANSMISSION LINE**

ENVIRONMENTAL/COST MATRIX

FACTOR	ALTERNATIVE ROUTES			
	(A) NORTH	(B) PARALLEL NORTH	(C) PARALLEL SOUTH	(D) DISMANTLE
Environmental / Technical	42,4	35,5	36,8	34,5
Length (kms)	17,23	16,23	16,71	16,38
Costs:-				
(i) Construction	R10 251 850,00	R 9 656 850,00	R 9 942 450,00	R 9 746 100,00
(ii) Land Values	R 983 135,89	R 875 034,55	R 924 628,95	R 907 015,87
(iii) Dismantling	0	0	0	R 2 500 000,00
Total Costs	R11 234 985,89	R10 531 884,55	R10 867 078,95	R13 153 115,87

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Hydra - Gamma 765 kV, 1992.

4.2 BIOLOGICAL ISSUES

4.2.1 NATURAL VEGETATION

This area has a "upper non-succulent karoo" vegetation of the types (Map 7):

(a) the "False Upper Karoo" (36) covering the northern area from De Aar to Gamma, where the hills are of the grassveld type, with *Rhus erosa* as the principal shrub and the plains covered mainly by the Karoo shrub species *Eriocephalus/Pentzia* and *Eragrostis/Aristida* grass species.

(b) the "Central Upper Karoo" (27) covering the zone south of the Gamma substation, which does not differ much from the above type, except that it has less grassiness and the characteristic shrub of the hills is the *Rhus burchellii*

There are no rare or endangered plants presently known to occur in this area (Vlock, J H, 1991). There are some uncommon succulent species in the area (Appendix 4), and the possible occurrence and localization may have to be done when the route centre line is defined.

The Karoo bush takes a long time to regrow from the trampling of the plants and compaction of the soil along the access road and around the towers. The farmers complain about this prolonged loss of vegetation and the possible erosion caused by the lack of root system in the soil.

The above-facts are significant but of small magnitude in the context of the homogeneous vegetation throughout the area and the rehabilitation and erosion control measures that are implemented afterwards.

Taking the above into consideration and the fact that the uncommon plants are very localized and avoidable, the impact is moderate.

Sources of information - "Veld types of S.A" (J P H Acocks - 1988), "The Karoo biome" - SA National Scientific Programmes Report

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Hydra - Gamma 765 kV, 1992.

Assessment - A comparison between the three routes, gives an advantage to the "yellow" (B), as it has less bend towers.

This group has a distinctive advantage over the "black" route with the shorter line lengths (-R1 496 000), less number of bends towers (-R500 000) and the absence of side slope, becoming cheaper and easier to build.

It has, though, the rejection of the land-owners already affected by the other line, who would then prefer to have it parallel (black).

5.1.3 ALTERNATIVE E (RED)-(MOST WESTERN ROUTE) (MAP 3)

This option was identified, having in mind a route that would be as much as possible away from the existing line and have the same characteristics of the others.

That meant breaking away from the others at the railway bottleneck and then developing southwards, with a separation of about 4 to 8 km from the existing power line. The same criteria used for the B, C and D alternatives was applied here in respect of avoiding farmhouses, rugged terrain, erosion, etc.

For 70 km after the bottleneck, the terrain is flat, only broken by 2 small ridges near Merriman, Kamrant and Perderant, which have easy saddles to cross.

The Bulberg mountain is in the way of this alignment and 20km before the Gamma site, the route turns eastwards to avoid it (Fig. 5.1.3).

-The length of this option is 126,5 km
The middle group options (yellow, green and blue) are on average 126,0 km, so it is 0,5 km (+R440 000) longer. But in relation to the parallel (black) it is shorter by 1,2 km (-R 1 056 000)

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Pegasus - Athene 400 kV, 1992.

5.0 CRITERIA USED IN THE SELECTION AND EVALUATION OF A TRANSMISSION LINE ROUTE²

At regional scale, the selection of the corridor for the 400 kV transmission line was based on a series of criteria which in addition to cost have varying degrees of influence on route location. These criteria are as follows:

Criterion		Approximate Level of Constraint/Opportunity
1.	Conservation	
+	Terrestrial vegetation	Slight
+	Terrestrial & avian fauna	Slight
+	Proclaimed nature reserves/natural heritage sites	Severe
+	Private nature reserves	Moderate-severe
+	Wetlands	Severe
+	Scenic areas	Moderate-severe
+	Historic/archaeological sites	Moderate-severe
+	Recreational sites	Severe
+	Tourist areas	Severe
+	Game ranching areas	Moderate-severe
2.	Existing Agriculture	
+	Arable	Slight
+	Orchards & vineyards	Moderate
+	Irrigation	Moderate
+	Forestry	Severe
3.	Agricultural Potential	
+	Grazing	None
+	Dryland arable	Slight
+	Irrigation	Moderate
+	Forestry	Moderate-severe
4.	Urban Development	
+	Existing settlement	Severe
+	Future settlement	Moderate-severe
+	Health	Undetermined

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Pegasus - Athene 400 kV, 1992.

5. Rural Development

+	Existing settlement	Severe
+	Future settlement	Moderate-severe

6. Mining Development

Constraint/Opportunity

7. Existing Transmission Line

Opportunity

Each of the above is described in greater detail in the remainder of this section.

5.1 Conservation

5.1.1 Terrestrial Vegetation

The potential physical impact of a 400 kV transmission line in a savanna environment depends on the extent of bush clearing for the construction and maintenance of the line. In countryside where the bush is dense and soil-water conditions have encouraged tree growth, bush clearing may be very noticeable and involve a large number of trees.

Eskom policy has been to minimise bush clearing as far as possible. In the Matimba-Spitskop project, for example, the line was constructed through dense bushveld with a trace width of only 6 m (Eskom, pers comm Mr H van Tonder). This is not generally favoured by Eskom construction teams because of the increased risks of snagging during line stringing, but it is possible, if necessary. Under less restricted conditions, Eskom prefer to cut a trace approximately 12 m wide. Trees are bulldozed and moved to the edge of the trace. When required, they are left in situ for ecological reasons (for the development of localised niches). Otherwise, they are trimmed and removed from the site. Access is as far as possible along the alignment and from existing roads and tracks. Under these conditions, bush clearing for a 400 kV line would amount to 1,2 hectares per linear kilometre.

The ecological significance of bush clearing of this magnitude is mainly a question of the conservation value of the habitat through which the route is aligned, and the risk of erosion caused by clearing. Where the veld types represented are not threatened, the conservation significance depends on whether the specific area is a pristine habitat or is intended as part of a natural heritage site or for any other conservation purpose.

As far as erosion is concerned, any form of heavy construction in areas of high erosion potential represents a risk to terrestrial ecosystems. In areas of steep terrain and erodible soils, nick points caused by stripping of vegetation along the route or along access roads may channel surface runoff, initiating gully or sheet erosion. Erosion potential is a function of soil erodibility and slope gradient and length. Experience of impact management along Eskom lines has shown that erosion control is rarely a problem when erodible soils are not combined with steep slopes (ie: in the absence of steep slopes, erodible soils can be managed to prevent problems and therefore need not influence decisions about route location).

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Pegasus - Athene 400 kV, 1992.

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TABLE 4: ZONE 3 : IMPACTS OF THE TRANSMISSION CORRIDOR ALTERNATTIVES BETWEEN NONDWENI AND UMFOLOZI SUBSTATION

Criterion	Impact				Remarks
	None	Slight	Mod	Severe	
Conservation					
+ Terrestrial vegetation		o x +			
+ Terrestrial & avian fauna		o x +			
+ Proclaimed & proposed nature reserves	o x +				
+ Natural heritage sites	o x +				
+ Private nature reserves	o x +				Route 3 has no impact on the private conservancies Doornkroon 412, Doornhoek 991 & Bokide 153.
+ Wetlands		o x +			Any small areas of hydromorphic soils to be identified during surveying of the preferred route. Tower positions and access roads to avoid these areas.
+ Scenic areas	+	x		o	Route 1 has a severe impact on viewlines from the Nhlazatshe mountain.
+ Historic/archaeological sites		o x +			A detailed archaeological survey of the preferred route is required.
+ Recreation sites	o x +				
+ Tourist areas	+	x	o		
+ Game ranching	o x +				
+ Erosion sensitive areas		o x +			Soils with moderate erosion susceptibility. Some precautions will be necessary during construction.
Existing Agriculture					
+ Arable		o x +			
+ Orchards	o x +				
+ Irrigation	o +		x		Irrigation along the Mvutshini River.
+ Forestry	o x +				
Agricultural Potential					
+ Dryland		o x +			
+ Irrigation	o +		x		
+ Forestry	o x +				
Urban Development					
+ Existing settlement	o x +				
+ Future settlement	o x +				
+ Health	o x +				
Rural Settlement					
+ Existing settlement	o x +				Vryheid and Beberango districts, Natal
+ Future settlement	o x +				
Mining Development					
+ Existing mining	o x +				
+ Future mining	o x +				

o Route 1

x Route 2

+ Route 3

(refer to Figure 8 for location of the routes)

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Pegasus - Athene 400 kV, 1992.

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Landscapes along all of the route alternatives will be subject to erosion hazard during construction, particularly across the pediments near Ngutu. Construction impact must be controlled, using the methods described in Section 10. A further threat concerns the risk which active headward erosion of existing gullies poses for nearby tower positions. Control of this problem will require careful tower placement, and where necessary, gabions and regrading to contain existing gulleys.

8.4.3. Zone 3: Nondweni to Umfolozi Substation (Table 4 refers)

From Nondweni the route passes through the Babanango and Vryheid districts of the RSA. The main issue in this zone concerns visual impact in the Nhlazatshe mountain area. The importance of conserving the aesthetic and natural quality of the landscape around the Nhlazatshe mountain was raised by the SA Wildlife Society.

Figure 9 details the existing development in the vicinity of Nhlazatshe. The southern approach is disturbed as a result of six existing utilities:

- + Main Road 34;
- + the Vryheid-Ulundi railway line;
- + separate incoming 400 kV lines from Camden power station and Pegasus substation;
- + the Umfolozi substation;
- + two outgoing 400 kV lines to Melmoth and Richards Bay;
- + outgoing 88 kV lines to Ulundi.

Route 1 has severe visual impact. The towers will be clearly visible from the northern side of the mountain and together with the gravel road will represent the only discernable human intrusion into the natural landscape panorama to the north.

Route 2 parallels the existing incoming 400 kV line from Pegasus and although clearly visible from Nhlazatshe will not significantly change existing visual relationships southward from the mountain.

Route 3 is favoured since it increases the distance between the mountain viewsite and the transmission line. At this distance, the towers will be invisible to the naked eye once the galvanising dulls to matt grey. At distances greater than 5 km against a terrestrial background, the conductors are invisible and the towers themselves are difficult to see. The tower positions of the existing 400 kV-line shown in Figure 9 to the south of main road 34 (Point A) could only just be discerned with the naked eye from the Nhlazatshe viewsites. There is also the potential to make use of the natural terrain in order to conceal sections of the line behind the crest of the intervening hill. The best alignment in this regard can be determined during detailed survey.

Route 3 has no significant impact on the game-fenced conservation areas on the farms Doornkroon 412, Doornhoek 391 and Bokkie 153 (Figure 10). The route has been discussed with the owner of Doornkroon 412, who has no objection to the alignment (pers comm with Mr J O'Naldy on 28 April 1992).

Case study EIR: Pegasus - Athene 400 kV, 1992.

8.5 Comparison between the Route Alternatives

Between Pegasus substation and Ulundi (Zones 1-5, Figure 8) Route 3 is the preferred corridor for the following reasons:

- i) it has little ecological impact. No recognised wetlands are affected. No threatened species or communities are affected. Erosion hazard in the Nqutu district is important but can be controlled by impact management during line construction. No proclaimed or potential nature reserves, national heritage sites, private game farms or any other conservation areas are affected. Bird markers are required on the line near Nhlazatshe in order to reduce possible collisions with the line by Cape Vultures in particular. A colony of these birds is present in the area;
- ii) no resettlement will be necessary in KwaZulu. This is the most critical drawback of Routes 1 and 2, both of which will result in resettlement of approximately 40-50 households;
- iii) visual impacts are slight. Although the route does not follow a corridor of existing visual disturbance, sites of scenic importance are not severely affected. Although a short section of the route between the Umfolozi River and the Umfolozi substation includes interesting scenery, the private conservancies within this area are not affected. Unlike Routes 1 and 2, viewlines from the Nhlazatshe mountain will not be disrupted. The aesthetic advantages of Route 2, parallel to the existing 400 kV lines are therefore small and are outweighed by the route's impact on rural settlement and Eskom's need to ensure a secure source of supply to Alusaf and Richards Bay (point vi refers);
- iv) no (known) sites of historic, pre-historic or cultural importance are affected. Confirmation of the absence of pre-historic and cultural sites will need detailed field survey and discussion with the tribes, once the route has been pegged. Identification of any sites is unlikely to influence the route alignment, but may result in the adjustment of tower positions and access roads;
- v) impact on urban settlement is slight. The route skirts the north-eastern perimeter of Ulundi, but is outside of the proclaimed area and is on average 500 m from the residential development;
- vi) the route minimises the risk of catastrophic power supply failure. Parallel routes of 400 kV supply increase the risk of the failure of two lines simultaneously due to veld fires. The simultaneous loss of two 400 kV lines could reduce Eskom's capability of supplying power to Richards Bay by up to two-thirds. In the present case, maintenance of supply to Alusaf and other industries is vital. Alusaf, in particular, would suffer extreme production and financial losses as a result of a power failure.

Between Ulundi and Richards Bay (Zones 6-10), no major alternatives to the proposed Route 4 corridor were considered. Since the 88 kV line does not supply bulk power to Richards Bay, there is no technical constraint affecting parallel routes. The proposed alignment within the Route 4 corridor will deviate from the 88 kV line only in cases where it is necessary in order to avoid impact on rural settlement.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Hector 400 kV, 1994.

The central section of the study area either side of the N3 highway, is situated at slightly higher altitudes. The landscape slowly descends southwards to an average height of 750m before rising again into the Ngomankulu Mountain in the south - west and the mountains bordering Mpumalanga in the south - east. North of the N3 highway, the terrain begins to resemble the valley of a thousand hills, with a myriad of hills making up the terrain north of Camperdown.

High altitudes are associated with steep slopes, remote access and topographical constraints. In addition, higher altitudes impose technical limitations such as poor insulation capacities. High altitudes are also prone to more lightning strikes and severe weather conditions. A power line at high altitudes could be visually conspicuous and therefore the pylons are, if possible, not placed on skylines and at high altitudes, but rather in valleys, at the foot of mountains or on lower land.

6.2.4 DRAINAGE

The Mlazi River is a major land feature within the study area providing much opportunity for intensive agriculture. The River meanders through the southern part of the study area between Ngomankulu and Mpumalanga.

6.2.5 CLIMATE

The macro-climate is fairly similar throughout the study area. However, the micro-climate varies according to the topography and local conditions. The major characteristics of the climate are as follows:

- a. Average daily maximum temperatures vary between 19° and 27°C.
- b. Average daily minimum temperatures vary between 3°C and 15°C.
- d. Rainfall varies between 700 mm and 1000 mm per annum
- f. Sunshine duration varies from 50% to 60% of the possible in summer and in winter from 70% to 80%.
- g. Winds are mainly southerly and northerly to north westerly, the latter often very strong especially in autumn (Climate of South Africa, Weather Bureau, 1986)

The study area lies in an area that has a relatively high incidence of lightning strikes i.e. between 6 and 8 flashes per square kilometre per year (CSIR, 1986).

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Hector 400 kV, 1994.

6.4.2 RAILWAY LINES

The main railway line between Durban and the Transvaal runs almost parallel to the N3 highway and the old main road. A second railway line runs parallel to the tar road between Thornville and the N3. "As of now, no future railway lines are anticipated" - Spoornet
The railway lines in the study area pose no problems to the construction of a powerline.

6.4.3 PIPELINES

Two large pipelines run through the northern part of the study area, north of Camperdown and Cato Ridge (Map 3). These pipelines would have to be avoided by careful tower positioning, were a northern route to be followed. No major pipelines occur in the rest of the study area.

6.4.4 POWER LINES

The study area is covered by an extensive low voltage reticulation system. Several high voltage power lines traverse the study area.

- * Georgedale - Venus 275 kV parallel lines
- * Georgedale - Mersey 275 kV parallel lines
- * Mersey - Hector 275kV line
- * Georgedale - Illovo 275kV parallel lines

Public response has suggested that a route parallel to the existing Georgedale - Venus 275kV lines be followed. The suggested route would entail the crossing of the existing Georgedale - Mersey 275kV lines which enter the study area from the north. Were a northern route to be followed, the same lines would have to be crossed. A southern route would entail the crossing of the existing Georgedale - Venus 275kV lines on two occasions.

6.4.5 TELECOMMUNICATIONS

This issue is defined as all forms of long distance communications and includes:

- * SABC Broadcasting Towers
- * Telkom Network
- * Transtel Microwave Network

Case study EIR: Ariadne - Hector 400 kV, 1994.

CHAPTER 7

DISCUSSION

At the outset of the environmental investigation, the boundaries of the study area were defined according to economical and topographical constraints. Understandably, Eskom would prefer the straight line between the two substations. Such a route makes sense financially. It includes a minimum amount of bends and incurs no additional costs due to increased line length. The Environmental Impact Assessment has been designed to identify a corridor between the substations which impacts minimally on the total environmental biome. Such a corridor would have taken into account political, cultural, social, economic, and technical issues. The chosen corridor may or may not be the straight line between the two substations.

Information relevant to the study area was then collected to identify the main issues in the area. Interested and affected parties, the public and landowners were given the opportunity to participate in the investigation by means of a public participation phase. Following the public participation phase, three issues emerged as the most important regarding the study area.

7.1. Environmental

The environmentally sensitive area to the north of the study area emerged as an important issue. The agricultural potential of the area is low due to the low rainfall in the area. Although an existing powerline, the quarry and a racetrack occur in the area, the dry thornveld gives the area a natural feel. The Environmental Sensitivity Atlas for Kwazulu\Natal, has identified the area as Oribi habitat.

7.2. Agriculture

Perhaps the biggest impact to the landowners in the study area will be on the current land use.

Current land use could be impacted by the transmission line in the following ways:

- i. Alteration of current land use.
- ii. Interference with land use practices.
- iii. Sterilisation of land.
- iv. Division of economic land use units.
- v. Introduction of a safety and security risk to the current land use.
- vi. Cessation of current land use.
- vii. Devaluation of real and intrinsic value of the land.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Hector 400 kV, 1994.

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SUMMARY OF IDENTIFIED ISSUES WITHIN THE STUDY AREA AND THEIR POTENTIAL IMPACTS				
Environmental issues	Study area sections			Remarks
	Northern	Middle	Southern	
Bio physical aspects				
Geology	Low	Low	Low	Tower foundations, costs
Relief	High	Low	Low	Access to tower positions
Drainage	Low	Low	High	River crossings
Climate	Low	Low	Low	Lightning, wind speeds
Vegetation	Low	High	High	Largely commercial agriculture
Wetlands	Low	Moderate	Moderate	
Fauna	Low	Low	Low	Birds, mammals
	1	2	3	
Socio - economic issues				
Land - use	Low	High	High	Vegetables, sugar cane
Conservation areas	Low	Moderate	High	Conservancies
Environmental sensitivity atlas	High	Low	Low	Unprotected areas.
Roads	Moderate	Low	Low	New proposed N3
Railway lines	Low	Low	Low	
Pipelines	Low	Low	Low	Petronet pipelines
Power lines	Low	Moderate	High	Parallelism
Telecommunications	Low	Moderate	Moderate	Interference
Airfields	Low	High	High	Private, microlights
Dams	Low	Low	High	Proposed Killarney dam
Quarries	Low	Low	Low	Minimum distance
Proposed developments	High	High	High	Ultra city and Illovo sugar mill
Agriculture	Low	High	High	Sugar cane, smallholdings
	1	2	3	
Socio - cultural issues				
Tourism and recreation	Moderate	Low	Moderate	Low potential
Archaeological sites	Low	Low	Low	Low priority
Aesthetics	High	High	High	Valley of a thousand hills
	2	4	3	

Once the main issues within the study area had been identified, Eskom then appointed an external consultant Mr G. Nicolson (Guy Nicolson Consulting Services) to review the environmental investigation. Mr Nicolson's review was based on the information collected, including the responses from the landowners.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Venus 400 kV, 1995.

TABLE 8.2 CATEGORIES OF CONCERN WITHIN THE STUDY AREA (CONTINUED)

TOURISM	Activity elements such as angling, camping, walking, hiding and hunting, para-sailing, hang-gilding, ecotourism, guest houses and hotels. Viewing elements viz. Physical landscape elements such as waterfalls and rapids, rock formations, land forms, topographical features, fauna and flora; Cultural landscape elements i.e. cultural patterns and man-made structures; Historical place elements viz. historical and geological; Visual impact and areas of scenic beauty.
LAND USE	Current land use practices viz. afforestation, sugar cane, cultivated areas, dairy, grazing, irrigation, areas of crop spraying, livestock, retirement holdings, smallholdings and studs of all kinds
PRIORITY FLORA	Species with a conservation status of endangered, vulnerable or rare.
PRIORITY FAUNA	Species of avifauna, mammals and butterflies with a conservation status of endangered, vulnerable or rare.
PROTECTED AREAS	Proclaimed nature reserves, biospheres reserves, conservancies, natural heritage sites, Natal Parks Board's identified sites of conservation significance and areas of critical environmental components.
WETLANDS	Effect on the geohydrological system, excluding associated fauna and flora.
RELIABILITY OF SUPPLY	Wind effect on power lines, risk of fire, effects of mist belt

IMPACTS ASSOCIATED WITH THE CATEGORIES OF CONCERN

8.3

In this section:

- The potential impacts on the study area in respect of each category of concern are described.
- The impacts are assessed by the author in terms of specific criteria commonly used in the IEM procedure.
- The potential for mitigating negative impacts and/or enhancing positive impacts is discussed.

The criteria and descriptions used in this process are shown in Table 8.3.

An attempt has been made to address both the potential impacts of the transmission line on the study area and of the potential impacts of the study area on the transmission line.

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TABLE 8.1: SUMMARY OF ISSUES OF CONCERN RAISED BY INTERESTED AND AFFECTED PARTIES FROM APRIL 1993 TO JULY 1993 (LONBAND, 1993) (CONTINUED)

SPECIFIC CONCERNS	NUMBER OF REPLIES	% OF TOTAL REPLIES
Impact on commercial viability and/or tourism	37	31
Threats to livestock	35	29
Interference with irrigation	28	23
Loss of commercial forests	27	22
Impact on buildings or residences	16	13
Interference with dams and/or irrigation planning	32	26
Interference with crop spraying or aviation	18	15
Impacts during construction activities	21	17
Health impacts	2	2
Wind effect on power lines	18	13
Risk of fire	8	7
Lines in mist belt	1	1
General e.g. Erosion, difficult topography, access to the line, radio and TV reception, historical and archaeological sites, compensation payable to landowners	30	25
Total number of replies	121	

* THE SUM OF THE NUMBERS OF REPLIES PRESENTED DOES NOT EQUAL THE TOTAL NUMBER OF REPLIES, AS RESPONDENTS RAISED MORE THAN ONE ISSUE PER RESPONSE.

All issues of concern raised by IAPs and others identified in the examination of the study area in Chapter 7, have been grouped in logical 'categories of concern' (Table 8.2).

TABLE 8.2 CATEGORIES OF CONCERN WITHIN THE STUDY AREA

CATEGORY	ISSUES INCORPORATED INTO EACH CATEGORY
TECHNICAL	Access, erosion, topography, lightning, altitude.
INFRASTRUCTURE	Roads, railway lines, telecommunication and broadcasting facilities, dams, agricultural installations, power lines, pipelines, air fields, buildings and residences, any man-made structures and proposed new developments, quarries.
ECONOMICS	Capital cost of the project, length of line.
ARCHAEOLOGY	
POPULATION DENSITY	Effect of Electromagnetic fields (EMFs).

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In Chapter 9, this analysis is fine-tuned for each of the alternative corridors, and, in addition, a significance rating for potential impacts associated with each category of concern for each corridor is determined. The suite of significance ratings for each corridor can then be compared, allowing selection of the most appropriate corridor.

TABLE 8.3: SUMMARY OF CRITERIA USED FOR THE ASSESSMENT OF THE CATEGORIES OF CONCERN

DESCRIPTION	CRITERIA	DESCRIPTION OF SUB ACTIVITIES OR ELEMENTS THAT ARE CENTRAL TO EACH ISSUE.
ASSESSMENT	Nature	What causes the effect? Who will be affected? What will be affected? How will it be affected?
	Status Extent	Either positive, negative or neutral. Is the impact site specific, i.e. extending as far as the activity? Does the impact extend locally, i.e. extend to the site and its immediate surroundings? Does the impact extend regionally, i.e. have an impact on the region of the KwaZulu-Natal Midlands? Does the impact extend nationally, i.e. have an impact on a scale within the South Africa's boundaries? Does the impact extend internationally, i.e. have an impact on a scale beyond South Africa's boundaries?
Duration	Short term, i.e. 0-5 years.	Medium term i.e. 5-11 years
	Long term, i.e. impact ceases after the operational life cycle of the activity either because of natural processes or by human intervention.	Permanent, i.e. mitigation either by natural process or by human intervention will not occur in such a way or in such a time span that the impact can be considered transient.

TABLE 8.3: SUMMARY OF CRITERIA USED FOR THE ASSESSMENT OF THE CATEGORIES OF CONCERN (CONTINUED)

Intensity		Low, i.e. natural and social functions and processes are not affected or minimally affected.
		Medium, i.e. affected environment is notably altered. Natural and social functions and processes continue albeit in a modified way.
		High, i.e. natural or social functions or processes could be substantially affected, or altered to the extent that they would temporarily or permanently cease.
	Probability	Improbable, i.e. possibility of impact to materialise is very low either because of design or historic experience.
		Possible, i.e. there is a distinct possibility that the impact will occur.
		Probable, i.e. it is most likely that the impact will occur.
		Definite, i.e. the impact will occur regardless of any prevention measure.
	Cumulative or non-cumulative	Potential of two or more impacts to combine to form cumulative or synergistic impacts.
	Level of certainty	Prediction is certain (i.e. high level of confidence) or uncertain.
	Risk	High, medium or low risk associated with the impact
MITIGATION	Reversibility	Impact is reversible or irreversible.
	Potential to mitigate each of the negative impacts	Description of the mitigation measures. Extent to which mitigation measures will influence the significance and status of each impact.
	Potential to optimise each of the positive impacts	Description of the optimisation measures. Extent to which they will influence the significance and status of each impact.

8.3.1. TECHNICAL

8.3.1.1 Description of issues

Technical issues and possible impacts to be considered during the choice of a transmission line corridor include access, erosion, altitude, lightning and topography.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Venus 400 kV, 1995.

8.3.10.2 Assessment

a) Extent and Duration

The extent of the possible impact on protected areas is considered by the elements of the protected area as well as the status of the protected area. Proclaimed state and private nature reserves are likely to contain elements recognised as having either regional or national value and importance to nature conservation and/or ecotourism. Therefore, any impacts thereon could have regional to national implications. The extent and duration of the possible impacts of a transmission line on the different elements of the issue are defined in Table 8.9.

TABLE 8.9: SUMMARY OF THE EXTENT AND DURATION OF THE IMPACTS ON THE ELEMENTS OF PROTECTED AREAS.

ELEMENT	EXTENT	DURATION
Proclaimed and Private Nature Reserves	Nationally or Regionally	Long term
South African Natural Heritage Sites	Nationally or Regionally	Long term
Biosphere reserves	Locally or Regionally	Long term
Conservancies	Locally or Regionally	Long term
Sites of Conservation Significance	Locally or Regionally	Long term
Critical Environmental components	Locally or Regionally	Long term

b) Intensity

The intensity could be from low to high, and would increase in proportion with the number of protected areas affected, and the higher their protected area status. The construction of a transmission line across protected areas would alter the affected environment but natural and social functions and processes would continue albeit in a modified way. The intensity of the impact is thus considered medium. The intensity could be expected to be high where proclaimed or private nature reserves, and South African Natural Heritage sites occur.

c) Probability

It is considered probable that there would be impacts on protected areas without mitigation.

Case study EIR: Ariadne - Venus 400 kV, 1995.

TABLE 9.3 THE DISTANCES OF EACH CORRIDOR TRAVERSING THE FIVE DRY LAND CROP POTENTIAL CLASSES OF THE STUDY AREA (DISTANCES ARE PRESENTED AS PERCENTAGES OF THE TOTAL LENGTH OF THE CENTRE LINE OF EACH CORRIDOR)

CORRIDOR	LOW	LOW-MEDIUM	MEDIUM	MEDIUM-HIGH	HIGH
A	34	6	8	46	6
B1	37	6	11	28	18
B2	42	4	12	33	9
C	37	6	12	36	9
D	35	8	21	19	17
E	49	11	21	13	6
F	70	2	20	1	7
G	36	6	19	21	18

TABLE 9.4 THE EXPECTED POPULATION DENSITIES ALONG EACH CORRIDOR TRAVERSING THE STUDY AREA (DISTANCES ARE PRESENTED AS PERCENTAGES OF THE TOTAL LENGTH OF THE CENTRE LINE OF EACH CORRIDOR)

CORRIDOR Alternative	Line Length (Km) through urban areas	Line Length (Km) through rural areas	No. of People in servitude area in rural areas
A	0	152	776
B1	0	128	641
B2	0	128	643
C	0	128	597
D	2	117	351
E	24	92	100
F	12	113	108
G	10	110	458

9.3.1 CORRIDOR A

Corridor A traverses the most remote parts of the study area, and is the longest of all of the routes.

9.3.1.1 Technical

Corridor A traverses altitudes ranging from 900 m up to 1900 m. The high altitudes pose a higher risk than the lower altitudes with regard to the insulating and isolating capacity of the air and the frequency of lightning, severe storms and snow falls. The performance of an installation at high altitudes can be expected to be less reliable than at lower altitudes.

Corridor A traverses topographically difficult terrain with restricted access, especially in the Impendie-Wuthering Heights areas. The terrain in this area

An analysis of land uses along the centre line of the eight corridors is presented in Table 9.1. This table was derived from information gathered from analysis of recent Russian satellite imagery (1983) and "groundtruthed" by GISinfo.

A matrix summarising the agricultural activity along each corridor is presented in Table 9.2.

Table 9.3 summarises the expected dry land crop potential along the eight corridors as derived from the ISCW (1995).

Table 9.4 presents the expected population densities along each of the corridors.

TABLE 9.1 MATRIX OF THE MAIN CLASSES OF LAND USE FOUND ALONG EACH CORRIDOR THROUGH THE STUDY AREA (DISTANCES ARE PRESENTED AS PERCENTAGES OF THE TOTAL LENGTH OF THE CENTRE LINE OF EACH CORRIDOR)

Landuse	A	B1	B2	C	D	E	F	G
Agriculture	21	23	18	23	28	17	11	33
Commercial Forestry (Plantations)	13	15	16	16	14	17	23	12
Rural Settlements	20	15	15	25	25	22	19	17
Sugar Cane	4	6	5	5	2	7	6	1
Scrubs & Forests	42	41	46	31	33	28	31	37
Natural grassland	No wetlands are indicated as no wetlands were recorded on the centre line							
Wetlands	No urban areas are indicated as they would obviously be avoided							
Urban areas								

TABLE 9.2 MATRIX FOR THE MAIN CLASSES OF AGRICULTURE FOUND ALONG EACH CORRIDOR (DISTANCES ARE PRESENTED AS PERCENTAGES OF THE TOTAL LENGTH OF THE CENTRE LINE OF EACH CORRIDOR)

Agriculture type	Corridor							
	A	B1	B2	C	D	E	F	G
Subsistence	14	14	17	13	6			1
Small holding	14	6	7	32	10	37	37	6
Irrigated	42	42	33	35	11	17	18	16
Dry land	30	38	43	20	73	46	45	77
Poultry			1	1				

Case study EIR: Ariadne - Venus 400 kV, 1995.

9.3.2 CORRIDOR B1

This corridor is approximately 127,8 km in length and lies at a lower altitude than corridor A.

9.3.2.1 Technical

This corridor poses the same technical difficulties in the southern and northern sectors as corridor A. The central part of the corridor traverses undulating land and valleys. The corridor is easily accessible by provincial, public and private roads. The crossing of the Mooi River along this corridor would not pose serious technical problems.

CRITERIA	IMPACT ASSESSMENT: BEFORE MITIGATION	IMPACT ASSESSMENT: AFTER MITIGATION
Extent	Regional	Regional
Duration	Long term	Long term
Intensity	Medium	Low
Probability	Probable	Possible
Certainty	Certain	Certain
Risk	Medium	Low
Reversibility	Reversible	Reversible

9.3.2.2 Infrastructure

This corridor crosses the two 275 kV Georgedale-Venus transmission lines on the Baynesfield Estate. It also crosses the Kamberg 88 kV tee-line in the area of Heighten 3470. These crossings of existing powerlines will call for higher towers to ensure sufficient clearance distances.

In addition to the crossing of transmission lines, Corridor B1 crosses several district roads, rural power and telephone lines as well as the Pietermaritzburg-Underberg railway trajectory. It crosses the N3 highway and the main Durban-Johannesburg railway lines in the vicinity of Ennersdale.

The corridor passes quite close to an SABC and a telecommunication tower. The location of a transmission line along this corridor will not influence the performance of these towers.

APPENDIX II (continued): EXAMPLES OF EIA METHODS USED IN CASE STUDIES EXAMINED IN SECTION 4.1.

Case study EIR: Ariadne - Venus 400 kV, 1995.

The above table can be summarised as follows.

In respect of the natural environment

- * Corridors A, B1, B2 and C are likely to have adverse impacts of **Very High** significance on *Priority Fauna*, in particular the endangered Wattled Crane. Corridors D, E, F and G could also impact on *Priority Fauna* but the significance rating is somewhat lower, although still **High**.
- * Corridors E and F have **High** significance ratings for *Priority Flora*, mainly because of the potential impact on indigenous forests, compared to **Medium** ratings for all other corridors.
- * Corridor E has a **High** significance rating for *Protected Areas*. Corridors D, F and G have a **Medium** rating, and other corridors a **Low** rating based on the number and nature of the protected areas found in the vicinity of each corridor.
- * Corridors A, B2 and C could have adverse impacts of **Medium** significance on *Wetlands*, compared to **Low** for all the other corridors.
- * All the corridors are considered to have a **Low** significance rating for adverse impacts on *Archaeology*.

In respect of the human environment:

- * Corridors C, E and F have a **High** rating with regard to *Land Use*, mostly because of the intensity of land use, while the other corridors are rated **Medium**.
- * Corridors A and E have a **High** rating for *Tourism*, due to their pristine nature and or/the importance of tourism assets, while all other corridors are rated **Medium**.

SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES
PRESENTED IN SECTION 4.2.

Case study EIR: Kendal - Midas 400 kV, 1990.

BIOPHYSICAL FACTORS: FAUNA

Collision/electrocution: Not recognised.

Rare/endangered species: Recognised and evaluated in terms of *"nature reserves (dominant/endangered species)"*. Resulted in mitigation, since nature reserves are regarded as exclusion zones and are avoided in route selection.

Nesting/roosting/movement: Not recognised.

Electricity supply loss: Not recognised.

Changed habitat: Not recognised.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised, evaluated and mitigated for, in terms of *"interference with natural vegetation"* on alternative route "D". Resulted in mitigation in the form of avoidance.

Conservation status: Recognised and evaluated in terms of *"natural vegetation (red data species)"*. Resulted in mitigation in the form of avoidance.

Alien vegetation threat: Not recognised.

Economic value: Not recognised.

Debris disposal: Not recognised.

Wind damage: Not recognised.

Herbicide use: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Kendal - Midas 400 kV, 1990.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently evaluated in terms of *"land form"* and *"transmission line construction costs"* having *"low"* and *"high"* impacts respectively.

Soil stability/slope: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently evaluated in terms of *"land form"* and *"transmission line construction costs"* that resulted in mitigation in the form of avoidance.

Wetlands/drainage lines: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently evaluated in terms of *"water resources"* and *"wetlands"*, both having *"low"* impacts.

Weather conditions: Recognised and evaluated in terms of *"climate"* having *"low"* impact.

Geotechnical: Recognised and evaluated in terms of *"geology"* and *"transmission line construction costs"* having *"low"* and *"high"* impacts respectively.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised generically in a list of *"areas/terrain to be avoided"* and subsequently evaluated in terms of nature reserves as exclusion zones, agricultural activity impact being higher where lands are irrigated, *"shooting range (low)"*, *"explosives magazine (low)"* and *"mining (low)"*. Resulted in mitigation in the form of avoidance and optimising on existing boundary lines.

Future land use, per type: Recognised and evaluated in terms of the expansion of a nature reserve. Resulted in mitigation, due *inter alia* to *"the reservation of vast tracts of proposed areas for urbanisation of low income population"* causing avoidance.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Kendal - Midas 400 kV, 1990.

Transportation systems: Recognised generically in a list of *"areas/terrain to be avoided"* and subsequently evaluated in terms of *"railway line"*, *"roads"*, *"oil and gas pipelines"*, *"major transmission lines"*, *"airfields"* and *"microwave towers"*, all of which are regarded as having *"low"* impact.

Tenure/fabric: Recognised and evaluated in terms of *"tourism"* and *"recreation potential"* having *"low to moderate"* and *"low"* impacts respectively.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: Not recognised.

Line: Not recognised.

Form: Not recognised.

Colour: Not recognised.

Texture: Not recognised.

Absorption/insertion: Recognised and evaluated in terms of *"aesthetics"*, with the existing *"assortment of public services"* being mentioned specifically in mitigation, in the form of reduced visual impact.

SOCIO-ECONOMIC FACTORS: STAKEHOLDER

Consumer: economic development: Not recognised.

Landowner: property value: Recognised and evaluated in terms of *"human settlements"*, *"industrial land"* and *"transmission line construction costs"*, with their impacts given as *"very high"*, *"high"* and *"high"* respectively.

renunciation: Recognised and evaluated in terms of *"human settlements"* and *"industrial land"*. Resulted in mitigation in the form of avoidance of neutralising land for other use.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Kendal - Midas 400 kV, 1990.

Community: consumerism: Not recognised.

cultural resources: Recognised and evaluated in terms of *"history"*
and *"archaeology"*. Resulted in mitigation in the form of avoidance
of an historic farm house and an ancient village.

resettlement: Not recognised.

labour: Not recognised.

services: Not recognised.

ELECTROTECHNICAL FACTORS: SERVITUDE

Compensation: Recognised and evaluated in terms of *"transmission line
construction costs"*. Resulted in mitigation in the form of rejection of option *"H"*
due to excessive servitude acquisition costs.

Line configuration: Recognised and evaluated in terms of *"transmission line
construction costs"* having *"high"* impact.

Dimension: Not recognised.

ELECTROTECHNICAL FACTORS: CLEARANCES

Horizontal/vertical: Not recognised.

Mid-span/tower: Not recognised.

Security/public safety: Not recognised.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Not recognised.

Audible noise: Not recognised.

Radio interference: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Kendal - Midas 400 kV, 1990.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently evaluated in terms of *"railway line"*, *"roads"*, *"oil and gas pipelines"*, *"major transmission lines"*, *"airfields"* and *"microwave towers"*. Although these impacts are all regarded as *"low"*, mitigation did result, in the form of attempted optimising on existing powerline servitudes and clearance concerns at road crossings.

Timing of activities: Recognised and evaluated in terms of delays causing additional costs. Resulted in mitigation where the more expensive *"I"* option avoided possible conflicts later.

Technical optimisation: Recognised and evaluated in terms of *"transmission line construction costs"* like line length, tower type and the number of bends having a *"high"* impact.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: Not recognised.

Pollution: Not recognised.

Access: Recognised generically in a list of *"areas/terrain to be avoided"* and subsequently evaluated in terms of *"transmission line construction costs"* where access is regarded as having a *"high"* impact.

Costs: Recognised and evaluated in terms of *"access road, tower foundations type, servitude acquisition, line length and number of bend towers"*, *"future maintenance"* and *"uneven and erodable ground, soil type, land value and topography"*. Resulted in mitigation in the form of cost trade-offs and avoidance.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

BIOPHYSICAL FACTORS: FAUNA

Collision/electrocution: Recognised and initially evaluated by overlay mapping, where *"fauna"* is described in terms of known collisions with birds on existing lines in the study area. Resulted in mitigation in the form of minimisation by means of visually obvious markers being stipulated for *"the vicinity of Muldersvlei substation"*.

Rare/endangered species: Recognised and initially evaluated by overlay mapping, where *"fauna"* is described in terms of endangered or vulnerable reptiles and amphibians known of in the study area.

Nesting/roosting/movement: Not recognised.

Electricity supply loss: Not recognised.

Changed habitat: Not recognised.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised and evaluated in terms of the *"removal of several large trees and windbreaks"* on the *"historical farm Bellevue"*. Resulted in mitigation in the form of avoidance, for instance, at the *"farmstead Bellevue"*.

Conservation status: Recognised and initially evaluated by overlay mapping, where *"nature conservation sites"* in the study area are described in terms of the value of veld types. *"Endangered habitats"*, as one of 12 *"environmental factors"* is subsequently evaluated numerically, per corridor and route, in matrices of impacts where it is awarded a weight of 1,4 out of 5,0. Mitigation resulted, in the form of avoidance of a particular hill, with the *"invasion of exotic plant species"* after *"disturbance of the natural veld type"* being cited as the major factors.

Alien vegetation threat: Recognised, evaluated and mitigated, as per previous paragraph.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

Economic value: Not recognised.

Debris disposal: Not recognised.

Wind damage: Recognised but not explicitly evaluated in terms of the *"removal of several large trees and windbreaks"* on the *"historical farm Bellevue"*.

Herbicide use: Not recognised.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Not recognised.

Soil stability/slope: Recognised and initially evaluated by overlay mapping, where *"relief"* in the study area is described in terms of the various slopes of the hills. *"Topography"*, as one of 12 *"environmental factors"*, is subsequently evaluated numerically, per corridor and route, in matrices of impacts where it is awarded a weight of 1,0 out of 5,0.

Wetlands/drainage lines: Recognised and initially evaluated by overlay mapping, where *"drainage"* is described in terms of the relative size of the three rivers in the study area.

Weather conditions: : The *"low incidence of lightning"* is a decision-factor in the recognition and evaluation of the *"risk of parallelism"* in the option of erecting the proposed line adjacent to existing lines.

Geotechnical: Recognised and initially evaluated by overlay mapping, where *"geology and soils"* are described in terms of distinctive synclines and anticlines, and four soil types. *"Soil type"*, as one of 12 *"environmental factors"*, is subsequently evaluated numerically, per corridor and route, in matrices of impacts where it is awarded a weight of 0,9 out of 5,0.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised and initially evaluated by overlay mapping, where *"farming"*, *"mineral resources"* and *"residential development"* are described in terms of their present value and suitability. *"Farming"*, *"mining"*, *"residential development potential"* and *"soil fertility"*, as four of 12 *"environmental factors"*, are subsequently evaluated numerically, per corridor and route, in matrices of impacts where they are awarded weights of 5,0, 3,3, 2,5 and 1,4 out of 5,0 respectively. Resulted in mitigation in the form of avoidance, for instance, at the *"Country Fair"* chicken farms.

Future land use, per type: Recognised and initially evaluated by overlay mapping, where *"residential development"* is described in terms of its future suitability. Also evaluated in terms of the future expansion of the *"Salvation Army property"*. Resulted in mitigation in the form of avoidance, for instance, at the *"future extensions of Haasendal"*.

Transportation systems: Recognised and initially evaluated by overlay mapping, where *"freeways and roads"* are described in terms of the affect on properties and future connections.

Tenure/fabric: Not recognised.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: Recognised and initially evaluated by overlay mapping, where *"aesthetics"* are described in terms of the visual affects on three routes used by visitors to wine farms, as well as the vista from a prominent hill. *"Aesthetics"*, as one of 12 *"environmental factors"* is subsequently evaluated numerically, per corridor and route, in matrices of impacts where it is awarded a

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

weight of 2,0 out of 5,0. Resulted in mitigation in the form of avoidance, for instance, at the *"farmstead Bellevue"*.

Line: Not recognised.

Form: Recognised and evaluated in terms of the *"greater visual impact"* of higher towers on the farms *"Bellevue and Haasendal"*.

Colour: Not recognised.

Texture: Not recognised.

Absorption/insertion: Recognised and initially evaluated by overlay mapping, where *"aesthetics"* are described in terms of the *"concentration of transport services"* of roads and a railway line. A route following a *"Provincial Main Road (R101)"* is evaluated as having a negative impact, since it *"produces the maximum visual damage because of high visibility to many travellers"*. While the impact is acknowledged, no specific mitigation is offered.

SOCIO-ECONOMIC FACTORS : STAKEHOLDER

Consumer: economic development: Not recognised.

Landowner: property value: *"Size of property"* and *"homesteads"* are recognised and evaluated numerically in matrices of impacts, per corridor and route, as two of 12 *"environmental factors"* where they are awarded weights of 1,7 and 1,4 out of 5,0 respectively.

renunciation: The possible expropriation of two homes on the farm *"Aldenburgh 1355"* indicate recognition and evaluation of this impact, inter alia. Resulted in mitigation in the form of minimisation, for instance, since *"fewer homes, outbuildings and cottages will be expropriated"*, by adopting the *"northern parallel route"*.

Community: consumerism: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

cultural resources: Recognised and initially evaluated by overlay mapping, where *"historical features"* are described in terms of the location of seven homesteads that have National Monument status, and *"archaeology"* in terms of Early Stone Age artefacts and deposits of Miocene peat. The reference to a *"low"* potential for *"recreation"* in the study area is also recognised and evaluated here, with a hiking trail, golf courses, an equestrian farm and a sports club being listed. *"Heritage"* and *"recreation"*, as two of 12 *"environmental factors"*, are subsequently evaluated numerically, per corridor and route, in matrices of impacts where they are awarded weights respectively of 2,0 and 1,0 out of 5,0. Resulted in mitigation in the form of avoidance of *"higher recreational impact on the Kuils River Golf Course"*.

resettlement: Recognised and evaluated in terms of *"new dwellings built for the affected owners"*, if residences on the *"De Novo property"* were demolished to make way for one of the route options.

labour: Not recognised.

services: Not recognised.

ELECTROTECHNICAL FACTORS : SERVITUDE

Compensation: Recognised and evaluated in terms of *"current land values for different land uses"*, as these relate to cost implications.

Line configuration: Not recognised.

Dimension: Recognised and evaluated in terms of the *"additional restricted area of 15,5 m required for the dismantling option"*.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

ELECTROTECHNICAL FACTORS : CLEARANCES

Horizontal/vertical: Not recognised.

Mid-span/tower: Recognised nominally as not interfering with the *"normal use of farming vehicles and machinery"*.

Security/public safety: *"Induced voltages in fence wires, farm outbuildings or residences"* were recognised and evaluated as impacts and mitigated by means of stipulating the earthing of structures.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Recognised nominally, but no evaluation or mitigation offered.

Audible noise: Recognised nominally, but no evaluation or mitigation offered.

Radio interference: *"Distortion of the antenna radiation pattern"* was recognised and evaluated as an impact, with mitigation resulting in the form of a prescribed 1000 m minimum distance between the proposed line and a telecommunications tower in the study area.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: The positive impact of optimising on an existing 132 kV overhead powerline servitude was recognised and evaluated. This would entail dismantling a line to vacate part of the servitude, which would then be available for the proposed 400 kV line. A negative impact was recognised and evaluated in terms of the *"technical problems in crossing the proposed National Road N7 interchange"*, and the two existing 132 kV powerlines in the study area. Resulted in mitigation in the form of avoidance, for instance, at the *"proposed National Road N7 interchange"*, as well as minimisation, where the powerlines are

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Muldersvlei - Stikland 400 kV, 1990.

"concentrated within a narrow corridor" on the proposed "northern parallel route".

Timing of activities: The scheduling of the *"reconstruction of Provincial Main Road (R101)"* is recognised and evaluated. Recognition, evaluation and mitigation of this impact are also provided in the avoidance of construction activities during the picking and pressing of grapes, and during winter rainfall.

Technical optimisation: The *"spacing of towers"* was recognised as having an impact but was left to a post-EIA stage, when the profile of the line was to be established. Evaluation occurred, inter alia, in the form of possibly placing self-supporting towers on two fruit farms, to reduce the loss of productive land. Resulted in mitigation in the form of avoidance and minimisation, for instance, by the *"judicial placing of towers on Farm 221/1"*, i.e. over fences or on roads.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: The *"low incidence of veld fires"* is a decision-factor in the recognition and evaluation of the *"risk of parallelism"* in the option of erecting the proposed line adjacent to existing lines.

Pollution: Not recognised.

Access: Not recognised.

Costs: Construction costs in monetary terms, per corridor and route, based on distance and hardware required, are recognised and evaluated. Compensation for affected properties also included here.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

BIOPHYSICAL FACTORS : FAUNA

Collision/electrocution: Recognised and evaluated in terms of no *"concentration of bird species susceptible to collision"* occurring in the study area, with a resulting *"moderate"* impact.

Rare/endangered species: Recognised and evaluated in terms of the endangered riverine rabbit occurring in the study area, and receiving a *"low"* impact since the proposed line is not a particular threat to this species.

Nesting/roosting/movement: Impact on nesting was recognised in terms of raptors' nests occurring on existing lines, but was evaluated as *"moderate"*.

Electricity supply loss: Not recognised.

Changed habitat: Not recognised.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised nominally as resulting in impact, with reference to a generic procedure for *"prescribed rehabilitation"*.

Conservation status: Recognised generically in a list of *"areas/terrain to be avoided"*, in terms of *"conservation areas"*. Subsequently evaluated as a *"moderate"* impact, in terms of *"no rare or endangered plants"* occurring.

Alien vegetation threat: Not recognised.

Economic value: Not recognised.

Debris disposal: Not recognised.

Wind damage: The high wind characteristics are recognised and evaluated as resulting in a *"moderate"* impact, in cases where vegetation no longer affords protection to the soil surface.

Herbicide use: Not recognised.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently, *"land form"* and *"erosion"* are evaluated as resulting in *"moderate"* and *"high"* impacts respectively and are mitigated by means of avoidance, where mountainous areas are *"circumvented to avoid increased erosion"*.

Soil stability/slope: *"Unstable"* conditions are recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently, *"sloped and unstable zones"* are evaluated in terms of *"erosion"* as resulting in a *"high"* impact and mitigated by means of avoidance.

Wetlands/drainage lines: Recognised generically in a list of *"areas/terrain to be avoided"*. Subsequently evaluated in terms of *"water resources"* receiving a *"low"* impact, and *"wetlands"* being non-existent in the study area.

Weather conditions: *"Climate"* is recognised and evaluated, in terms of the high wind characteristics causing a *"moderate"* impact.

Geotechnical: Recognised and evaluated in terms of *"geology"* and *"transmission line construction costs"* resulting in *"low"* and *"high"* impacts respectively.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised generically in a list of *"areas/terrain to be avoided"*, in terms of *"open-cast mining, human settlements, irrigated lands"* etc. No nature reserves occur in the study area. Evaluated in terms of the dominant land use of extensive stock farming receiving a *"low"* impact, and impacts on *"human settlements"* and *"mining and quarrying"* also being *"low"*.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

Future land use, per type: Recognised and evaluated in terms of *"future expansion"* of the *"town of De Aar"* destined to be in a direction away from the proposed line, therefore receiving *"low"* impact.

Transportation systems: Recognised generically in a list of *"areas/terrain to be avoided"*, in terms of *"aerodromes, railway lines and telecommunication towers"*.

Railway lines, roads, airfields and telecommunication towers subsequently evaluated as receiving *"low"* impacts due to avoidance and low traffic density

Tenure/fabric: Recognised and evaluated in terms of *"tourism"* and *"recreation potential"* not being great and resulting impacts thus being *"low"*.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: The impact from roads and farmhouses of the visual effect of the proposed line against the background of an *"empty landscape"* is recognised and evaluated as *"high"*. Mitigated by *"maximising the distance between them and the line"*.

Line: The impact of the proposed line where it crosses ridges (*"skylining"*) is recognised and evaluated as *"high"*. Mitigated by *"positioning the cross-over on their lower points"*, i.e. using the topography to disguise the proposed line.

Form: Not recognised per se but see next two paragraphs.

Colour: The *"contrasting effect of size, colour and texture"* is recognised as a visual impact and is evaluated in the absorption of the proposed line into the landscape.

Texture: The *"contrasting effect of size, colour and texture"* is recognised as a visual impact and is evaluated in the absorption of the proposed line into the landscape.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

Absorption/insertion: Recognised and evaluated. Maximising the distance between the proposed line and those places from which it will be seen, particularly farmhouses, is a form of mitigation by means of absorption, i.e. minimising the visual appearance of the line.

SOCIO-ECONOMIC FACTORS: STAKEHOLDER

Consumer: economic development: Not recognised.

Landowner: property value: Recognised and evaluated in terms of the *"repetitive impact on already impacted farms"* undermining the value of farmland. Resulted in mitigation in the form of avoidance, through spacing the proposed transmission line a considerable distance from existing lines.

renunciation: Not recognised.

Community: consumerism: Not recognised.

cultural resources: Recognised and evaluated in terms of *"history"* and *"archaeology"* receiving *"low"* impacts, due to the location and magnitude of such sites in relation to the proposed line.

resettlement: Not recognised.

labour: Not recognised.

services: Not recognised.

ELECTROTECHNICAL FACTORS: SERVITUDE

Compensation: Not recognised.

Line configuration: Not recognised.

Dimension: Not recognised.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

ELECTROTECHNICAL FACTORS: CLEARANCES

Horizontal/vertical: Not recognised.

Mid-span/tower: Not recognised.

Security/public safety: Not recognised.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Not recognised.

Audible noise: Not recognised.

Radio interference: Not recognised.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: Impact on existing transmission lines recognised and evaluated as *"high"*, due to technical problems associated with *"parallelism increasing common cause faulting"* and *"increasing tower density in a strip already impacted"*. Mitigation resulted in the form of avoidance, in the selection of a route further removed from existing lines.

Timing of activities: Not recognised.

Technical optimisation: Not recognised.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: Recognised and evaluated in terms of *"the possibility of faults due to veld fires"* being *"remote"*, since the incidence of lightening is low and the sparse Karoo vegetation is not likely to burn readily.

Pollution: Not recognised.

APPENDIX II (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Hydra - Gamma 765 kV, 1992.

Access: Recognised generically as an impact, in terms of access roads being allowed *"in accordance with guidelines, only where necessary"*. Evaluated in terms of erosion having to be *"monitored along the access road"*.

Costs: Recognised, evaluated and mitigated by means of avoidance of mountainous areas, to *"circumvent higher construction costs of an increased number of bend towers and line length"*.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

BIOPHYSICAL FACTORS: FAUNA

Collision/electrocution: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on *"bird species prone to collision"*. Evaluation resulted in mitigation by means of stipulating bird markers *"to reduce possible collisions with the line by Cape vultures in particular"*.

Rare/endangered species: Recognised and evaluated in terms of *"threatened species or communities"*. Mitigated by means of avoidance, e.g. Route 3, Zones 1-5 having *"little ecological impact"*.

Nesting/roosting/movement: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"bush clearing"*.

Electricity supply loss: Not recognised.

Changed habitat: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"habitat lost in clearing the corridor"*.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"bush clearing"*. Evaluation resulted in mitigation, in the form of avoidance of a *"strip of riverine forest"*.

Conservation status: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on the *"conservation value of the habitat"*. Evaluation resulted in mitigation by means of avoiding *"proclaimed or potential nature reserves"*.

Alien vegetation threat: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

Economic value: Not recognised.

Debris disposal: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"localised ecological niches"*.

Wind damage: Not recognised.

Herbicide use: Not recognised.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of the *"risk of erosion caused by clearing"*. Evaluation resulted in mitigation in the form of protection of *"soils with high erosion susceptibility"*, e.g. at tower bases in Zone 2.

Soil stability/slope: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"slope gradient and length"*. Evaluation resulted in mitigation in the form of avoidance of *"steep terrain"* in the south of the study area.

Wetlands/drainage lines: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"infilling reducing water exchange"*. Evaluation resulted in mitigation in the form of avoidance, where *"no recognised wetlands"* are found within a particular route option.

Weather conditions: Not recognised.

Geotechnical: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on *"game farming"*, *"grazing and arable land"* and *"urban settlement"*. Evaluation resulted in mitigation in the form of avoidance of *"game fenced areas"* on certain farms, and *"dense settlements"* in some tribal authority areas.

Future land use, per type: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on the *"design of township layouts"* and in the possibility of a future dam on the *"White Mfolozi River"*.

Transportation systems: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"numbered roads and airfields"*.

Tenure/fabric: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on *"recreation and tourism"*.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: Not recognised.

Line: Recognised and evaluated, in terms of the visual impact of *"skylining"*, which resulted in mitigation by means of maximising the distance from which the line would be visible at *"Ulundi"*.

Form: Not recognised.

Colour: Recognised and evaluated in terms of *"towers being invisible to the naked eye, once the galvanising dulls to matt grey"*.

Texture: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

Absorption/insertion: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"compromised vistas"*. Evaluation resulted in mitigation in the form of *"increasing the distance between the mountain viewsite and the transmission line"*.

SOCIO-ECONOMIC FACTORS: STAKEHOLDER

Consumer: economic development: Not recognised.

Landowner: property value: Not recognised.

renunciation: Recognised and evaluated in terms of land being vacated through expropriation and resettlement. Although it amounts to renunciation, the communal nature of land ownership in rural areas makes this more of a community issue than an individual landowner issue.

Community: consumerism: Not recognised.

cultural resources: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on *"historic and prehistoric sites"*. Evaluation resulted in mitigation in the form of avoidance of *"many cultural and historic resources"* in the south of the study area.

resettlement: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact from *"expropriation of rural dwellings"*. Evaluated and mitigated by means of avoidance, e.g. in Zone 2, *"Route 3 avoids all settlements"*.

labour: Recognised and evaluated in terms of *"stringent control of construction worker camps"* being necessary. However, since this is

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

dealt with procedurally, it is not regarded as mitigation.

services: Not recognised.

ELECTROTECHNICAL FACTORS: SERVITUDE

Compensation: Not recognised.

Line configuration: Not recognised.

Dimension: Not recognised.

ELECTROTECHNICAL FACTORS: CLEARANCES

Horizontal/vertical: Not recognised.

Mid-span/tower: Not recognised.

Security/public safety: Not recognised.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact on *"community health"*.

Audible noise: Not recognised.

Radio interference: Not recognised.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: Recognised in a generic list of *"criteria used in the selection and evaluation of a transmission line route"*, in terms of the impact of *"existing corridors of visual disruption"*.

Timing of activities: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Pegasus - Athene 400 kV, 1992.

Technical optimisation: Recognised and evaluated in terms of *"making use of existing transmission line corridors"*, which resulted in mitigation in the form of *"minimising the proliferation of servitudes"* in the south of the study area.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: Recognised and evaluated as having an impact, when fires in sugar cane fields can cause outages. Mitigation resulted, in the form of contingencies such as *"lines of communication"* and *"fair warning"* systems being put into place.

Pollution: Not recognised.

Access: Recognised and evaluated in terms of *"severe cost penalties"* being associated with *"direct vehicle access"* on Route 2, Zone 4. Mitigation resulted in the form of avoidance and the selection of Route 3, where *"access is excellent from existing gravel roads"*.

Costs: Recognised and evaluated in terms of cost impacts that would result from supply failure. Mitigation is provided in the form of minimising *"the risk of failure of two lines simultaneously"*, by avoiding parallel lines.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Hector 400 kV, 1994.

BIOPHYSICAL FACTORS: FAUNA

Collision/electrocution: Recognised and evaluated in terms of species "*vulnerable to collisions with powerlines*". The "*wattled crane is clearly of greatest concern*" but does not occur in the study area.

Rare/endangered species: Recognised and evaluated in terms of the impact on "*fauna*" in the form of several listed "*birds and mammals*". No specific mitigation is offered.

Nesting/roosting/movement: Not recognised.

Electricity supply loss: Not recognised.

Changed habitat: Not recognised.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised as causing an impact but not specifically evaluated.

Conservation status: Recognised and evaluated in terms of "*natural biological communities*" and mitigated by avoiding a "*substantial area*" along "*route 3*".

Alien vegetation threat: Not recognised.

Economic value: Recognised and evaluated in terms of the impact on the "*vegetation*" that makes up "*commercial agriculture*".

Debris disposal: Not recognised.

Wind damage: Not recognised.

Herbicide use: Not recognised.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Vegetation removal was recognised as causing impacts but was not specifically evaluated in terms of resulting erosion.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Hector 400 kV, 1994.

Soil stability/slope: Recognised and evaluated in terms of the impact of *"relief"* on *"access to tower positions"*.

Wetlands/drainage lines: Recognised and evaluated in terms of the impact on *"drainage"* caused by *"river crossings"*.

Weather conditions: Recognised and evaluated in terms of the impact of *"lightning and wind speed"* due to *"climate"*.

Geotechnical: Recognised and evaluated in terms of the impact of *"tower foundations"*.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised and evaluated in terms of the impact on urban settlement in the form of *"necessary servitude width"*, on agriculture in the form of *"vegetables and sugar cane"*, and on conservation areas in the form of *"conservancies"*. Avoiding areas of *"highest agricultural potential"*, *"densely populated areas"* and *"two established conservancies"* served as mitigation.

Future land use, per type: Recognised and evaluated in terms of the impact of *"proposed developments"* in the form of a *"petrol station and sugar mill"*.

Mitigation resulted, in the form of avoiding *"areas along route 2 considered high in development potential"*.

Transportation systems: Recognised and evaluated in terms of the impacts on *"roads, railway lines, pipelines, telecommunication and airfields"*.

Tenure/fabric: Recognised and evaluated in terms of the impact on *"tourism and recreation"* in the study area.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Hector 400 kV, 1994.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: Recognised and evaluated in terms of the "aesthetic" impact on *"the Valley of a Thousand Hills"*. Mitigation resulted, in the form of *"the lines being elevated from the valley bottom"*.

Line: Recognised and evaluated in terms of the "visual impact" that would result from crossing the "skyline". Mitigated by means of routing the line "off the skyline".

Form: Not recognised.

Colour: Not recognised.

Texture: Not recognised.

Absorption/insertion: Recognised and evaluated in terms of the impact of "routes 1.3 and 1.4 running parallel to" a National road, and mitigated by avoiding these route options.

SOCIO-ECONOMIC FACTORS: STAKEHOLDER

Consumer: economic development: Recognised in terms of the "major cost to industry" that results from unreliable electricity supply due to episodic outages.

Landowner: property value: Recognised and evaluated in terms of the impact on "smallholdings" and mitigated by avoiding "routes 1.3 and 1.4".
renunciation: Recognised and evaluated in terms of expropriation and mitigated by avoiding concentrations of affected smallholdings "around the R56, Camperdown and Cato Ridge".

Community: consumerism: Not recognised.

cultural resources: Recognised and evaluated in terms of the impact on "archaeological sites" in the study area. The reference

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Hector 400 kV, 1994.

to avoiding these sites *"where possible"* is not regarded as mitigation.

resettlement: Recognised as in impact, in the event of *"demolition of dwellings"* to achieve legislative, access or security criteria. Dealt with further as property value and renunciation issues.

labour: Not recognised.

services: Not recognised.

ELECTROTECHNICAL FACTORS: SERVITUDE

Compensation: Recognised and evaluated as resulting in impact, where financial losses due to *"cane-free servitudes"* will need to be considered.

Line configuration: Not recognised.

Dimension: Recognised and evaluated in terms of increased impact where combined servitudes result in wider servitudes.

ELECTROTECHNICAL FACTORS: CLEARANCES

Horizontal/vertical: Recognised and evaluated in terms of the uneven terrain *"posing problems to clearance distances"*.

Mid-span/tower: Not recognised.

Security/public safety: Recognised in terms of secure areas for *"possible collapse of the structures"*.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Recognised and evaluated in terms of *"biological and health effects"*. The commitment to continual review of relevant research findings is not considered as mitigation.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Hector 400 kV, 1994.

Audible noise: Not recognised.

Radio interference: Not recognised.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: Recognised and evaluated in the mapping of *"existing powerlines"*.

Timing of activities: Not recognised.

Technical optimisation: Recognised and evaluated in terms of the advantages to grouping powerlines *"to consolidate areas in which it would not be possible to grow cane"*.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: Recognised and evaluated as impacting on line performance, due to *"sugarcane fires"*. *"Cane-free servitudes"* will serve as mitigation.

Pollution: Recognised and evaluated as impacting on line performance, due to *"pollution of insulators"*. *"Cane-free servitudes and insulator replacement"* will serve as mitigation.

Access: Recognised and evaluated in terms of the impact on *"access to tower positions"* caused by *"relief"*.

Costs: Recognised and evaluated in terms of the impact on costs that line length, tower type and number of bends have. Mitigation was provided in the form of selecting the longer, more costly but environmentally less intrusive route.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

BIOPHYSICAL FACTORS: FAUNA

Collision/electrocution: Recognised and evaluated in terms of the likelihood of birds colliding with earth wires rather than conductors and that *"electrocution is unlikely due to the distance between each of the conductors"*. Mitigation is recommended in the form of minimisation, by means of *"attaching line markers to the earth wire"*.

Rare/endangered species: Recognised and evaluated in terms of *"causes of mortality for each of the three crane species occurring in the study area"*. Note that the wattled crane (Grus carunculata) is a Red Data species. Mitigation is recommended in the form of avoidance of known habitats of *"vulnerable species"*.

Nesting/roosting/movement: Recognised and evaluated in terms of positive impacts resulting from the *"provision of perches and nesting sites"*. Providing such structures is recommended as mitigation.

Electricity supply loss: Not recognised.

Changed habitat: Recognised and evaluated in terms of *"destruction of habitats"* by *"interference with the vegetation"*. Mitigation is recommended in the form of general avoidance of areas where habitat changes would be extreme.

BIOPHYSICAL FACTORS: FLORA

Vegetation removal: Recognised and evaluated in terms of possible *"removal of vegetation at river embankments"* resulting in *"erosion"* impacts. Mitigation is recommended in the form of *"selective cutting of vegetation that poses hazard"*.

Conservation status: Recognised and evaluated in terms of vegetation removal resulting in *"the viability of remnant indigenous forest being threatened"*. *"Protected areas"* are described in detail. Mitigation is recommended in the form of avoidance of areas of *"priority flora"* and other *"protected areas"*.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

Alien vegetation threat: Recognised and evaluated in terms of *"encroachment of indigenous vegetation by alien invader species"*.

Economic value: Not recognised.

Debris disposal: Not recognised.

Wind damage: Not recognised.

Herbicide use: Not recognised.

BIOPHYSICAL FACTORS: PHYSICAL

Soil exposure/erosion: Recognised and evaluated in terms of *"irregular terrain"* causing increased soil erosion. Mitigation recommended in the form of *"avoiding sensitive areas"*.

Soil stability/slope: Recognised and evaluated in terms of *"irregular terrain"* causing impacts related to *"limitations in the operation of heavy construction equipment"*. Mitigation is recommended in the form of avoidance of areas of difficult terrain.

Wetlands/drainage lines: Recognised and evaluated in terms of *"the hydrological integrity of wetlands"* being impacted by the *"construction and maintenance of the transmission line"*.

Weather conditions: Recognised and evaluated in terms of *"high altitudes"* causing impacts in the form of *"poor insulation"*, *"more lightning strikes"* or *"failures induced by snow or high winds"*.

Geotechnical: Not recognised.

SOCIO-ECONOMIC FACTORS: LAND USE

Existing land use, per type: Recognised and evaluated in terms of the possible impacts on *"land use elements"* in a detailed list of mainly agricultural activities

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

(*"commercial forest, sugar cane, stock, vegetable farming, irrigation"* etc.) but also in terms of urban activity (*"population density"*). Mitigation is recommended in the form of avoidance of areas of *"high potential agricultural land"*, appropriate design such as *"increased span length"* etc.

Future land use, per type: Recognised and evaluated in terms of the impacts of *"any proposed and approved new developments"*.

Transportation systems: Recognised and evaluated in terms of the impacts on *"roads, railway lines, telecommunication facilities, pipelines and airfields"*. Mitigation is recommended in the form of avoidance of areas where a powerline would conflict with pipelines, for instance, by causing accelerated corrosion.

Tenure/fabric: Recognised and evaluated in terms of parts of the study area being *"a recreational terrain with medium potential"* and *"tourism significance not rated highly"*. Mitigation is nevertheless recommended in the form of avoidance of areas *"where there are regular, significant influxes of tourists"*.

SOCIO-ECONOMIC FACTORS: VISUAL

Homo-/heterogenous landscape: Recognised and evaluated in terms of *"not disturbing continuums of landscape units or vistas"*.

Line: Recognised and evaluated in terms of *"towers placed on skylines"* being *"visually conspicuous"*. Mitigation is recommended in the form of *"adaptation of design, e.g. lower towers"*.

Form: Not recognised.

Colour: Recognised and evaluated in terms of *"providing a dark backdrop for the line"*.

Texture: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

Absorption/insertion: Recognised and evaluated in terms of *"positioning the installation in low lying areas"*. Mitigation is recommended in the form of *"screening the installations behind trees or hills"*.

SOCIO-ECONOMIC FACTORS: STAKEHOLDER

Consumer: economic development: Recognised and evaluated in terms of the *"economic benefit to the end-user, stimulating economic activity"* in the region.

Landowner: property value: Recognised and evaluated in terms of the *"indirect costs of depreciation in land values"*.

renunciation: Recognised and evaluated in terms of the *"necessity of expropriation"* due to *"legal restrictions"*. Mitigation is recommended in the form of avoidance of areas of dense population.

Community: consumerism: Not recognised.

cultural resources: Recognised and evaluated in terms of impacts on archaeological sites, in the form of *"unauthorised access, destruction, intrusion, removal"* etc. *"Historical or archaeological sites"* are also listed as *"protected areas"*. Mitigation is recommended, by *"relocation, demarcation, access control"* etc., or complete avoidance by *"relocation of pylon positions"*.

resettlement: Recognised and evaluated in terms of the impacts on *"social, cultural, political and economic structures of affected communities"*. Mitigation is recommended in the form of avoidance of areas of dense population.

labour: Recognised and evaluated in terms of *"job creation"* by using *"local communities to maintain the servitude"*.

services: Not recognised.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE
EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

ELECTROTECHNICAL FACTORS: SERVITUDE

Compensation: Recognised and evaluated in terms of the proportion of the total capital cost of the line.

Line configuration: Not recognised.

Dimension: Not recognised.

ELECTROTECHNICAL FACTORS: CLEARANCES

Horizontal/vertical: Recognised and evaluated in terms of uneven terrain causing *"problems to clearance distances"*.

Mid-span/tower: Not recognised.

Security/public safety: Recognised and evaluated in terms of *"sufficient clearance distance needed underneath lines to prevent flashovers"*. Mitigation is recommended in the form of avoidance of areas of dense population.

ELECTROTECHNICAL FACTORS: ELECTRICAL EFFECTS

Electromagnetic fields: Recognised and evaluated in terms of the *"perceived health effects arising from EMFs"*. Mitigation is recommended in the form of avoidance of areas of dense population.

Audible noise: Not recognised.

Radio interference: Recognised and evaluated in terms of the impact on *"radio and television reception"* caused by *"corona interference"*. Mitigation recommended in the form of *"alterations or retrofitting of equipment that could eliminate interference"*.

APPENDIX III (continued): SUMMARY SHEETS IN SUPPORT OF THE EFFECTIVENESS RATING TABLES PRESENTED IN SECTION 4.2.

Case study EIR: Ariadne - Venus 400 kV, 1995.

ELECTROTECHNICAL FACTORS: DESIGN IMPLICATIONS

Existing infrastructure: Recognised and evaluated in terms of the impacts of *"several crossings of existing transmission lines"*. Mitigation in the form of higher towers *"to comply with legal prescriptions"* is recommended.

Timing of activities: Recognised and evaluated in terms of the influence that the *"time span of the project"* has on costs.

Technical optimisation: Recognised and evaluated in terms of the positive impacts of a *"reduced number of powerlines by stacking new and existing powerlines"*, notwithstanding the possibility of common cause faulting. Such optimisation is recommended as a means of mitigation.

ELECTROTECHNICAL FACTORS: ENGINEERING CONSTRAINTS

Episodic events: Recognised and evaluated in terms of *"threats to reliability of supply"* resulting from *"veld fires, cane fires, forest fires, lightning strikes, wind damage"* etc. Mitigation is recommended in the form of removal of flammable *"material containing high carbon contents"*.

Pollution: Recognised and evaluated in terms of *"threats to reliability of supply"* resulting from *"bird and other pollution"*.

Access: Recognised and evaluated in terms of *"lack of access roads to tower foundations"* having *"financial and environmental"* impacts. Mitigation recommended in the form of *"using a helicopter to construct powerlines, in severe cases"*.

Costs: Recognised and evaluated in terms of costs being *"proportional to line length"* and how *"access" and "non-standard design"* result in *"additional costs"*.